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ANNUAL REPORTS

OF THE

COMMITTEE ON SEWERS,

THE

SUPERINTENDENT OF SEWERS,

AND THE

CITY ENGINEER,

OF THE

CITY OF WORCESTER,

FOR THE YEAR ENDING NOVEMBER 30, 1889.

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WORCESTER
A TOWN JUNE 14, 1722 + A CITY FEBY. 29, 1848.

WORCESTER, MASS.:
PRINTED BY CHARLES HAMILTON,
311 MAIN STREET.
1890.

SEWER DEPARTMENT.

ANNUAL REPORTS

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Hill District and caring for the large amount of surface water which has been such an annoyance to the Rural Cemetery Corporation.

The trunk sewer for the relief of the New Worcester District has been partially constructed in Sutton Lane and Cambridge Street. This sewer is from 20 to 30 feet in depth and most of it in solid rock, and for these reasons tunneling has been resorted to with gratifying results. This work will be prosecuted during the winter months.

During the coming year some provision should be made for taking care of the waters of Hermitage Brook which takes the water shed of Millstone and the east side of Green Hills. A large deposit from the brook is brought into the sewer system, which is a cause of much annoyance and expense.

A system of sewers has also been constructed in the "East Shelby Street District," thus providing the much-needed relief to the section lying between East Park and Eastern Avenue.

A surface water sewer has been built in Leicester Street, beyond New Worcester, and has already proved a great benefit. This sewer can be used for no other purposes and is a part of the general plan of the district which provides for the division of surface water from the house sewage system.

The Committee would here recommend the early adoption of rules regulating the use of sewers in districts where the separate systems are to be used.

In addition to the trunk sewers, a large number of lateral sewers have been constructed in various parts of the City.

During the year another portion of the Mill Brook sewer, extending from Green Street to Lafayette Street, has been arched. The distance covered was 834 feet, and the expense of same $14,000.

The total expenditure for the year has been $158,588.61, divided as follows:—

Trunk Sewers,	$40,147 78
Lateral Sewers,	33,932 46
Maintenance,	14,065 08
Arching Mill Brook,	14,112 82
Purification,	56,330 47
	$158,588 61

In May, 1888, an appropriation of $75,000 was made by the City Council for the construction of an outfall sewer from the main sewer in Quinsigamond to the land below Quinsigamond purchased by the City for the purposes of sewage treatment.

During the early part of this year, this sewer was completed.

The Committee have given much time and thought to the subject of the final treatment of the sewage. Early in July, acting on recommendations from this Committee and by the advice of the City Engineer, an order was passed and an appropriation of $40,000 was made for the purpose of constructing a series of settling tanks, and purchasing machinery necessary for the disposal of the sludge. These tanks, six in number, have been built and are nearly ready for use.

Whatever plan shall finally be adopted for the treatment of the sewage these settling tanks will be a valuable and indispensable part of the system, and they have been constructed in the most thorough and substantial manner.

As the limit of time fixed by Legislative enactment expires early in the summer months, it is therefore an imperative necessity that very early in the year a decision should be made in regard to the system to be adopted for the treatment of the sewage.

In closing this report the Committee take pleasure in commending the faithfulness and efficiency of the Superintendent of Sewers, and the valuable aid rendered the department by the City Engineer in solving the many different problems which have arisen during the year.

F. A. HARRINGTON,
G. A. LONGLEY,
GEO. M. WOODWARD,
C. N. WALKER,
J. A. BRIGHAM,
ALEX. BELISLE, Jr.,
Joint Standing Committee on Sewers.

REPORT

OF THE

SUPERINTENDENT OF SEWERS.

To the Joint Standing Committee on Sewers:—

GENTLEMEN:—The report of the operations of the Sewer Department for the financial year of 1889 is as follows:—

The year has been a busy one, and although the additions to the sewer system have been smaller than in most recent years, the expenditures for sewer construction have been heavy and the results satisfactory.

The main sewer in Grove street, under construction at the opening of the year, has been completed, and the laterals built in North St., Powers Ct. and Milton St., relieving the pressing needs of that section.

The Crescent St. sewer has been extended 1062.5 feet, but must be still farther extended across the valley of Paine Brook and to Lincoln St. before it can be of any material benefit; the needs of the district are pressing, and the work should be done as early as possible.

A right of way has been acquired across land of the Henry Heirs and East Park, from Shrewsbury St. to East Shelby St., a main sewer built in it, and the laterals built in East Shelby St., Gage St., Prospect St., and Merrifield St., a very much needed improvement.

Expensive sewers were also built in Belmont St., Norfolk and Wall Streets, Tainter St., Main and Norwood Streets, Downing, Woodland and Charlotte Streets and in Vernon St. In all these considerable rock was found, making the average cost of sewers built during the year much greater than in many previous years. In addition to the above, a section of Mill Brook sewer between

Green St. and Lafayette St. has been arched; the difficulties of this work become greater each year with the erection of buildings adjoining the sewer, rendering it exceedingly troublesome to erect and maintain necessary machinery among them; if possible it should be continued in the near future.

The main sewer for the drainage of New Worcester has been partly completed in Cambridge St., Fremont St., and Sutton Lane, and is now under construction; this is the most expensive undertaking chargeable to sewer construction, that has occupied the department during the year; a ledge was developed on Fremont street of such magnitude that tunnelling was resorted to— a tunnelling plant consisting of a 10″ x 16″ Rand Air Compressor and four Rand drills and all necessary appurtenances were purchased— a forty-five horse-power boiler and an air receiver hired of Wm. Allen & Sons, and the work of tunnelling begun during the last days of August, since which time it has progressed steadily, and at a rate rarely equalled, considering the conditions under which it is done. Two pockets of earth have been met, but as they are being successfully tunnelled, no serious difficulty is apprehended from them; this sewer should be pushed to completion, and the laterals built as soon as possible.

A sewer for the care of surface water has been built in Leicester St. from Tatnuck Brook to Montague St. This sewer, and the one constructed last year at Quinsigamond Village, also for the care of surface water, form the beginnings of the separate system of sewers, which will be built wherever practicable, to exclude as far as possible all surface water from the sewage that the amount to be purified may be as small as possible. These sewers already built are for surface water only, and it should be so understood by the abutters; stringent rules should be adopted, regulating their use, and also the use of the sewers for sewage only, soon to be built. Your attention is particularly called to this matter, and it is hoped it will receive early consideration.

The following table shows the location, length, size and cost of all sewers built during the year, exclusive of the outfall sewer.

Preparation for purifying the sewage has been unremitting; work on the outfall sewer was continued during the winter, resulting in its completion early in the Spring; the gate and screen chambers were built, and are ready for the superstructures, gates, etc., and a portion of the swamp near Jefferds's rendering establishment, cleared of wood and stumps, and the wood sold.

July 8th, an order for constructing a series of sewage tanks passed the City Council, and work upon them was immediately commenced. A portion of the site selected for these tanks was located in the swamp above mentioned, the natural soil of which is a soft, black mud, varying in depth from one to nine feet. In order to provide suitable foundations for the tanks, it was necessary to excavate this mud and refill the excavation with material suitable to build upon. This was a work of no small difficulty, the natural conditions obtaining, and the large amount of material to be moved, rendering it necessary to employ unusual methods. A railroad was built across the swamp, and to the high ground adjoining, where it was elevated upon a trestle to provide dumping ground. A Carson excavator was employed to excavate the mud, which was dumped into cars and drawn out of the swamp to the trestle where it was dumped, by means of a stationary engine and cable, the cars returning to the swamp by gravity. Several thousand yards of mud were cheaply and quickly removed in this manner. The excavation was re-filled with gravel, which was carefully puddled and rolled, making a firm foundation for the masonry of the tanks. As soon as the grading would allow, masonry was begun and vigorously pushed. At present the tanks are complete, with the exception of the concrete bottom, which will be put in during the winter, a temporary roof protecting it from the cold.

This, with the construction of gate-houses, gates, connections, etc., will complete the works as far as is possible until some definite system of purification is adopted, which should be done immediately, as whatever process is finally decided upon the elaboration of its details will require considerable time, of which there is little to spare, if the statutory requirements are met.

A large amount of grading around the tanks will be necessary, involving a great waste of gravel, unless it can be used in converting another section of swamp into available land; it is recommended that the mud be excavated from sufficient area to accommodate what surplus filling there may be, and the excavation re-filled with gravel as the grading is done. The total length of the outfall sewer now built is 4986.3 feet, an addition of 1692.3 feet during the year.

The work of sewer maintainance has rapidly increased of late, partly owing to the extension of the sewer system, and partly because of necessary alterations and repairs, which are constantly increasing; one large item of expense, that for cleaning catch-basins, has increased heavily owing to the addition of many basins in streets having heavy grades, and without paved gutters, not only does the gutter wash fill the basins, but the rush of water carries much of the fine material into the sewer, to be deposited on the first light grade below, necessitating constant scraping in order to prevent a complete stoppage. It is hoped that arrangements may be made with the Highway Department, that will in a measure, obviate this difficulty, which is rapidly becoming serious with the extension of the sewers into the hilly districts in the suburbs.

Iron catch-basin covers are being substituted for the wooden ones formerly used, as it was found that the life of wooden ones is so short as to make their use very expensive, and that after decay has set in they are a constant source of danger; this item of expense has been heavy during the past year, and will be for the one ensuing, after which it should be materially less.

The sewers and their appurtenances are in good condition, as a rule, and are performing their service satisfactorily.

The headquarters buildings on the East Worcester Street lot have been completed, and have proved of great advantage in the work of the department. A telephone has been secured and located there, proving of great value.

The department now has storage and yard room sufficient to accommodate its plant and facilities for any light construction or repairs that may arise, a very great gain. Additions to the equipment of the department have been large, as will be seen by its increased value, as shown by the inventory.

Two large derricks of new and improved pattern have replaced the old ones, which were found to be unsafe for use; a double hoisting engine has been bought, in addition to the special machinery used in tunnelling; the plant is in excellent condition, and of sufficient extent to successfully prosecute any undertaking liable to arise.

The amount paid by this department for teaming of various kinds is very large; the recommendation made in the last annual report, relative to the purchase of an express team, is renewed; and it is further recommended that a pair of draught horses, together with necessary carts, wagons, etc., be purchased, and a stable erected on the East Worcester Street lot. It is hoped that these recommendations will receive favorable consideration, as it is believed that by their adoption a large annual saving is possible, beside largely increasing the efficiency of the department.

With the rapid extension of the sewers into suburban districts, and under our system of doing all work by day's labor, directly in charge of the Superintendent, necessitating the employment of large forces of men and material, it has become impossible for him to give the time to office detail that so large a system of works demands.

No adequate system of accounts is possible, and only the most general results are arrived at. The office of the department is closed to the public, with the exception of one hour during the day—an inconvenient arrangement, as the Superintendent must spend his time in personal contact with the work under his charge. The weekly pay-roll during the busy months is a labor of no small account, usually accomplished on the first day of the week, as there is no other available.

It is suggested that your Committee consider the advisability of employing a clerk during eight or nine months of the year, thus rendering a systematic accounting possible, from which the valuable facts regarding expenditure and results by different methods is readily deduced, deductions not now obtainable, or only in their crudest forms. The added convenience to the public of having the office of the department open during the day would be considerable, and the relief of the Superintendent from much that now necessarily occupies much time that is sorely needed for other duties would, it is thought, in no small measure return the outlay required.

Respectfully submitted.

RICHARD FOBES,

Supt. of Sewers.

REPORT OF THE CITY ENGINEER

TO THE

COMMITTEE ON SEWERS.

As there are many important matters in connection with the Sewer Department that seem to require a statement from me as Engineer, I have thought best, at this time, to make the following report:—

The central and more densely populated portion of the City is well provided with sewer accommodations; occasionally there will be found a street that has not, as yet, received attention; but in the main, very little more needs to be done. There are several districts, however, that will have to receive attention in the near future.

The first that I desire to call attention to is what is termed as the "ADAMS SQUARE DISTRICT." This is bounded in a general way by Perkins and Frederick streets on the south, the Boston & Maine Railroad and a portion of "Messinger Hill" on the west, the hills lying north of Millbrook street on the north, and the hills forming a portion of Mill Brook water-shed, on the east. It has an area of 417.82 acres. The main sewer, partly completed, is of brick. The line of this sewer is through the land of P. L. Moen, and a passageway between Millbrook, and Garden street, thence in Garden and Crescent streets to a point opposite Nashua street. Its size is 44″ x 66″ inside measurement from Mill Brook to the point where Paine Brook is intercepted, and 40″ x 60″ to its northerly terminus.

The plan for draining this district calls for extending Frederick street from its westerly end to Crescent street, and also for a new street to extend from the north end of Crescent street to a point on Lincoln street nearly opposite Washington Avenue.

It will be necessary to acquire the right of way in one or both of the localities named, at an early date.

The plans of the district are matured sufficiently, so that if the City Council should so decide, work can be continued without interruption, until all the sewers are constructed.

The Webster Square District is bounded by Gates Lane, Coes street, A. G. Coes' Pond, New Worcester Hill (so called), Lowell street and the southerly end of Richards street, the Boston and Albany Railroad, Hope Cemetery, Barnardville, Curtis Pond and Leicester street. It has an area of three hundred and seventy-nine acres, and is entirely without sewerage accommodations.

Profiles of all the streets have been made and the size of most of the sewers determined. The plans provide for two independent systems of sewers, separating the storm water (with the exception of roof water) from the sewage proper.

Short lines of large sewers are to conduct the surface water by the shortest course to the river which nearly divides the District, while the sewage will be taken into the general system by small sewers.

In designing the sizes of sewers for the different streets, the future growth in population of the district has been kept in view. The estimate of the quantity of sewage to be cared for is based upon a population of seventy-five persons to the acre, assuming that seventy gallons per day for each person will be the amount to be carried away. One seventh of the entire area is allowed for roofs, and a delivery of one-half inch in depth of rainfall per hour from this area is also provided for.

I consider it absolutely necessary that this general plan should be followed, not only in this district, but in every section of the City where it can be done, so as to reduce, as much as possible, the volume of sewage to be treated at the disposal works.

In this particular case, I recommend that the roof water be admitted as a means of flushing the sewers, rather than to resort to the use of flush tanks. Whenever this is insufficient, the sewers can be flushed from hydrants, as is the practice in other sections of the City.

The main sewer to conduct the sewage into the general system of sewers has been partly constructed. Its location begins at the Cambridge street sewer where it intersects with South Crystal street, and extends through Cambridge street to Fremont street, in Fremont street and Sutton Lane to Cambridge street again, and thence in Cambridge street to Webster Square.

The size when finished will be 30″ x 45″ to the intersection of Sutton lane and Cambridge street, and 28″ x 42″ for the remaining distance.

In order to reach Webster square, it is necessary to construct the sewer through the same ridge that the Crystal-street sewer tunnel was driven through several years ago. Investigation showed about the same quality of rock, and as the depth varied from twenty to thirty feet, it was decided to tunnel.

The work, so far, has been done in a most satisfactory manner by Mr. Fobes, superintendent of sewers, a detailed description of which will be found in his report.

As the inquiry has been frequently made as to the necessity of expending so much money—probably from $35,000 to $40,000—in constructing a sewer for the purpose of an outlet, when the sewage could be emptied directly into the river, at very much less expense, I think that perhaps it is proper for me to state, that the City is allowed, by the original sewer act of the Legislature, to empty sewage into the Blackstone river only through Mill Brook, and that if this were not so, the fact that the sewage has to be treated renders it necessary that it all be brought to one point.

A surface-water sewer has been constructed in Leicester street from the river to Montague street; this is of brick 18″ x 27″ as far west as Arborvitæ street and an 18″ pipe for the remaining distance.

THE QUINSIGAMOND DISTRICT

has not been surveyed as yet but will need early attention. Its location is such that I think it advisable to adopt the separate system, as in the case of the Webster square district.

The outfall sewer of the disposal system was designed to act as the main sewer into which the pipe sewers for house drainage of this district will discharge, while the storm-water sewers will run to the river by the most direct route.

SEWAGE DISPOSAL WORKS.

The outfall sewer, designed to conduct the sewage from the present channel of Mill Brook to the precipitation tanks, has been completed, with the exception of making the necessary connections with the brook and tanks.

This sewer is 42 inches in diameter and has a capacity of 12,500,000 gallons in 24 hours. It was located and constructed in accordance with the recommendations contained in my report to the city council in 1887, upon the question of sewage disposal. The estimated cost was $75,000 and there is now between $6,000 and $7,000 left of this appropriation. The plans in detail for the precipitation tanks were finished so that work could have been commenced early in the season, but owing to unavoidable circumstances, the order for their construction was not adopted by the city council until July 10th. Work was begun immediately.

A greater portion of the ground upon which the tanks rest was a swamp. The mud was removed from this and the space filled with well-puddled gravel.

Work upon the tanks was then begun. There are six of these, each being 66.66 feet wide and 100 feet long, inside measurement, and provide for a depth of sewage of five feet. They are located three upon each side of a central channel, through which the sewage will be discharged into them. The arrangement is such that they can be used intermittently or continuously, *i. e.*, each tank can be filled from the central channel and used independently, or the sewage can be passed through all of them,— precipitation taking place in each, before its final discharge into the effluent channel which will conduct the clarified sewage to the river. The outside and division walls are constructed of brick and stone laid in cement. The top of the wall is surmounted with a cap of Portland cement concrete. The floors of the tanks are of concrete and shaped so as to drain the sludge into a central channel, which will discharge into the main sludge drain.

Between the two sections of tanks, and under the sewage channel, is located the conduit in which will be placed the effluent pipe (used to empty the tanks of treated sewage, whenever it is desirable to clean them of sludge). and the main sludge drain. This drain is constructed of brick laid in Portland cement, and is built into the flow of the conduit, and is designed to carry the sludge to the sludge well.

The pipe is to be 18″ in diameter, and will discharge into the effluent channel.

The conduit has stone side walls laid in cement, and is arched with brick. The floor is of Portland cement concrete.

At each point, where the pipe connections are made, a side conduit is constructed so that the pipes are exposed to view except where they pass through the tank walls. The effluent channel is constructed of brick, and is arched for a portion of its length.

If the sewage is treated by the continuous process, the water will be discharged over a weir located at the end of the sixth tank, and will fall over stone steps into the effluent channel. If it is treated by the intermittent process it will be discharged through the effluent pipe into the channel.

The above is a brief description of the work done up to the present time. It is my purpose (with the consent of the Committee), to make a detailed report of the entire work when it is finished.

Photographs are taken of the work as it progresses, so that the report can be illustrated.

I think this should be done, as it will, in my opinion, be invaluable as a matter of record.

The appropriation for this work was $40,000. So far it has been done well within the estimate. This sum is supposed to cover the cost of sludge machinery, but does not include the cost of buildings and other things necessary for the plant.

It will be necessary to take early action upon the matter of

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sludge disposal, as well as the method to be adopted in treating the sewage.

In connection with sludge disposal, I would advise that the tract of land containing 20 acres, situated between the Providence and Worcester Railroad and the river, be added to the area already taken. This land is isolated, is of little value, and will be an excellent place to dispose of the sludge.

For the present, I recommend that the sludge be pumped onto this land and ploughed in. Eventually, I think that it will have to be pressed to extract the water, and so much of the "sludge-cake" as cannot be disposed of otherwise can be dumped at this place, without the least danger of becoming objectionable.

With the completion of the tanks, and the purchasing and setting of the machinery, the plant will be ready for work, and while much can be done toward helping the condition of the river by diverting from Mill Brook four or five millions gallons per day, and thoroughly treating it, the full result expected cannot be attained until the intercepting system is constructed through the City.

In the report of 1887, I recommended the construction of a separate conduit for Mill Brook, and using the present channel for sewerage purposes entirely. It is probable that this plan has many advantages over the plan of constructing intercepting sewers, upon each side of the brook; but until the details can be worked out and the two plans compared after a more thorough examination, I do not feel that it would be wise to accept either. Nevertheless, one of the two will have to be adopted in the near future, and I would recommend that the matter be investigated thoroughly during the coming year, so as to be prepared to act promptly whenever occasion requires.

The experience in construction during the last two years has demonstrated that the estimates made in the preliminary investigations are sufficiently large. I see no reason, therefore, for doubting but that the entire system, including appropriations already made, can be completed within the estimate made then, viz.: $322,758.75.

In closing, I wish to express my sincere thanks to the Committee for the courtesy extended to me on every occasion, and also to express my great appreciation of the able manner in which the Superintendent of Sewers and the Assistant Engineers have performed their arduous duties.

Respectfully submitted.

CHARLES A. ALLEN,

City Engineer.

WORCESTER, Dec. 27th, 1889.

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ANNUAL REPORTS

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OF THE

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THE

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AND THE

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REPORT OF THE JOINT STANDING COMMITTEE ON SEWERS.

In accordance with the provisions of the City Ordinances, the Joint Standing Committee on Sewers herewith submit their report for the year ending Nov. 30th, 1890, accompanied by the reports of the Superintendent of Sewers and the City Engineer.

The year just closed has been a very busy one in the Sewer Department, and the amount of work accomplished is unusually large and gratifying to your committee. During the season there has been constructed $4\frac{25}{100}$ miles of sewers, and in the entire system there is now $76\frac{59}{100}$ miles.

Early in the season the trunk sewer in Sutton Lane and Cambridge street for the relief of the New Worcester District was completed, and later in the year a sewer was constructed in Main street from Cambridge street to the top of New Worcester Hill. This sewer has brought relief to that portion of Main street, but in order that its full benefits may be enjoyed, quite a number of lateral sewers must, in the near future, be built in the several side streets.

The sewer in Crescent street for the relief of the Adams Square District has been extended to Sackville street, a distance of 1,397 feet. The committee feel that during the coming year this sewer should be completed to Lincoln street, and that a portion of the lateral sewers in that locality should be constructed in order that this thickly built section may receive the benefits of our sewer system.

A sewer for the drainage of the valley of Hermitage brook has been constructed through the Memorial Hospital estate, and lateral sewers have been built in East Kendall and Hooper streets. There is an urgent call for the continuation of this system quite a distance further north, to accommode the large number of houses that have been and are being built in that locality.

While the sewers built during the year have been scattered throughout all sections of the city, there has been a large amount of work done in the South Worcester District; also in Wall, Orient and Norfolk streets, in what is known as Oak Hill District.

Quinsigamond has not been forgotten. Last year a sewer was constructed from Quinsigamond, quite a distance up Vernon street, and this sewer has this year been extended a distance of 1,289 feet. A sewer has also been constructed in Perry street, a distance of 880 feet. This sewer was much needed, and will be much appreciated, as the street is well built upon, and the soil is very wet.

During the year another section of Millbrook sewer has been arched a distance of 547 feet from Lafayette street to Crompton Park at an expense of $10,027.28.

As the system grows larger year by year, the expense of maintenance must also materially increase. During 1889 and '90 a large number of the wooden catch basin covers have been replaced by iron ones, which are much safer, and in the end more economical.

The total expense for the year has been as follows:

Maintenance,	$14,731 38
Trunk Sewers,	33,228 56
Lateral Sewers,	25,745 88
Arching Millbrook,	10,027 28
Purification Works,	61,544 01
	$145,277 11

The tanks for purification purposes at Quinsigamond, which were in process of construction when last year's report was made, were completed early in the year, the work of concreting having been carried on during the winter months, the tank having been covered by a temporary roof.

The question of the purification of the city's sewage has been a serious problem for the committee to decide upon, but realizing that the limit of time fixed by legislative enactment was near at hand, the committee, after much thought and investigation of the various proposed methods of treatment, decided to recommend that the plan submitted by the City Engineer, Mr. Allen, viz., chemical precipitation, should be adopted.

In accordance with this decision, a suitable engine and boiler and the machinery necessary for grinding and mixing the chemicals, pumping the sludge, etc., was purchased, and placed in a building specially built for this purpose. So carefully and accurately was the work planned and so thoroughly constructed in all its details, on the 25th day of June the gate at Quinsigamond was raised and a portion of the city's sewage was taken by the outfall sewer to the purification works.

Upon the completion of the works, the committee selected Mr. Arthur A. Fobes, who had for some time been connected with the engineering department, to take charge of the same. Mr. Fobes has proved himself to be the right man in the right place; he has from the start been thoroughly interested in his work. On account of the large number of manufacturing establishments in the city using chemicals, the sewage is constantly changing in its nature, requiring at different hours of the day very different treatment. Such a thorough and scientific study has Mr. Fobes made of the matter, the result has been that the cost of treatment has been steadily reduced, while the results are equally satisfactory.

The City Engineer, Mr. Allen, in his report annexed has given a very complete and detailed description of the plant and of the results so far accomplished.

The committee will only add that they are well pleased with the manner in which the works have been constructed and with the work now being done.

Only a portion of the sewage is now being treated, and cannot be until the separation of the waters of Millbrook from our sewage system. The committee are of the opinion that in accordance with the recommendation of the City Engineer early in the coming year, the question of the construction of a separate channel for Millbrook should receive careful consideration. Should the channel be constructed, it is expected that the present plant with possibly a slight enlargement will be capable of treating the entire sewage for some years to come.

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[illegible] sewer has been [illegible] Crompton [illegible]

[illegible] expense of main- [illegible] and to a [illegible] have been [illegible] and in the end [illegible]

[illegible]

[illegible] the work of [illegible]

ing that the limit of time fixed by legislative enactment was near at hand, the committee, after much thought and investigation of the various proposed methods of treatment, decided to recommend that the plan submitted by the City Engineer, Mr. Allen, viz., chemical precipitation, should be adopted.

In accordance with this decision, a suitable engine and boiler and the machinery necessary for grinding and mixing the chemicals, pumping the sludge, etc., was purchased, and placed in a building specially built for this purpose. So carefully and accurately was the work planned and so thoroughly constructed in all its details, on the 25th day of June the gate at Quinsigamond was raised and a portion of the city's sewage was taken by the outfall sewer to the purification works.

Upon the completion of the works, the committee selected Mr. Arthur A. Fobes, who had for some time been connected with the engineering department, to take charge of the same. Mr. Fobes has proved himself to be the right man in the right place; he has from the start been thoroughly interested in his work. On account of the large number of manufacturing establishments in the city using chemicals, the sewage is constantly changing in its nature, requiring at different hours of the day very different treatment. Such a thorough and scientific study has Mr. Fobes made of the matter, the result has been that the cost of treatment has been steadily reduced, while the results are equally satisfactory.

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1898.

ANNUAL REPORT

OF THE

COMMITTEE ON SEWERS,

THE

SUPERINTENDENT OF SEWERS,

AND THE

CITY ENGINEER

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1890.

Worcester, Mass.:
PRESS OF F. S. BLANCHARD & CO.,
154 FRONT STREET.
1891.

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During the season arrangements were made with the P. & W. R. R. Co. for putting in a branch track so that coal and chemicals are now unloaded from the cars directly into the building, thus saving a large item in the way of cartage.

The committee are much pleased with the thorough and substantial manner in which the works have been constructed. The plant is a model one of its kind, and has been most favorably commented upon by various officials from other cities who have visited and examined the works.

We cannot close our report without again commending the intelligent and energetic manner in which the Superintendent of Sewers and City Engineer have performed their duties in connection with this department.

G. A. LONGLEY,
FRANCIS PLUNKETT,
GEO. M. WOODWARD,
JOHN S. BRIGHAM,
ALEX. BELISLE, Jr.,
IRVING E. COMINS,

Joint Standing Committee on Sewers.

REPORT OF THE SUPERINTENDENT OF SEWERS.

To the Joint Standing Committee on Sewers:

GENTLEMEN:—The report of the Superintendent of Sewers is as follows:

The sewer system, with some slight exceptions, is in good repair, and is performing its functions in a satisfactory manner. Minor changes and repairs are constantly being made, but none of an expensive nature have been necessary during the year. The annual cost of maintenance increases with the additions to the sewer system, and also because repairs and changes become necessary on the older structures. The heavy rains of the past season have rendered the work of cleaning catch-basins unusually expensive. This Department, acting with that of Highways, has paved the gutters in Montague street, and the benefit is quite apparent, not only in the diminished quantity of material washed into the catch-basins and sewer, but also in the appearance and safety of the street. It is thought that the work thus begun should be carried farther, and that most of the steep streets in the suburbs should be provided with paved gutters.

Nearly all the catch-basins are now fitted with iron covers, an expensive but permanent improvement, reducing the maintenance account for this item to a minimum.

Sewer construction has been vigorously pushed during the year, and the resulting additions to the sewer system have been large, as will be seen by the appended table. The main sewer for the drainage of the New Worcester district, under construction at the opening of the year, was completed early in the season, and later a lateral was built in Main street, from Webster square to Lowell street, affording much needed relief.

Crescent street sewer has been completed to Sackville street, but must be still farther extended to Lincoln street, and the laterals built, before it can be of value to the territory for which it is designed to furnish drainage. This should be done the coming year, as the needs of the district are pressing.

A sewer for the drainage of the valley of Hermitage Brook has been built across land of the Wasburn Memorial Hospital, from Belmont street to Kendall street, and laterals built in Kendall and Hooper streets, affording partial relief, but there is still much to be done in this section, as the valley north of Kendall street is totally without sewerage. Expensive sewers have also been built in Eastern avenue, Norfolk, Wall and Orient streets, Perry avenue and Suffield street, Vernon and Perry streets, at Quinsigamond Village, and in Mason street. Another section of Mill Brook has been arched, completing the arching to the northerly line of Crompton Park.

The following table shows the location,. length, size and cost of all sewers built by the Department during the year:

TABLE OF SEWERS CONSTRUCTED DURING FINANCIAL YEAR 1890.

STREET.	LOCATION.	SIZE. (Inches.)	LENGTH. (Feet.)	MANHOLES.	COST.
Edgeworth	Milton Street to Dryden Street	15	270.7	2	$579 58
	Dryden Street Curve	15	29.0	1	
Crescent	Extension to Sackville Street	40 x 60	1236 8	7	9666 60
		36 x 54	170.0		
Windsor	Extension northerly	12	267.6	2	425 65
Belmont St. Dist.	Belmont Street to Kendall Street (Through Washburn Hospital Estate.)	40 x 60	656.0	4	4266 31
Kendall	Hospital Estate to Hooper Street	12	286 5	4	1310 26
Hooper	Kendall Street southerly	12	249.2	3	
Eastern Ave.	Belmont Street to East Kendall Street	15	405.8	4	911 24
Eastern Ave.	Belmont Street southerly	12	672 6	5	945 61
Winona	Shrewsbury Street southerly	15	186.7	3	290 47
		12	121.4		
Shrewsbury	Larkin Street easterly	12	80.8	1	113 5[illegible]
Cullen Ct	Shrewsbury Street northerly	12	206.2	3	292 51
Norfolk	Wall Street easterly	16 x 24	99 7		503 74
Wall	Suffolk Street northerly	15	164.5	3	2039 08
		12	351.7		
Orient	Hamilton Street to Thorn Street	21 oval	472.6	6	1337 90
		15 "	247 8		
Harrison	Penn Avenue westerly	12	206 8	2	192 95
Ætna	Providence street easterly	12	242.1	3	318 70
Ward	Endicott Street to Richland Street	12	206.5	2	217 72
Perry Ave	Endicott Street to Suffield Street	15	265.5	2	1363 30
Suffield	Perry Avenue to Vernon Street	15	30.4	6	
		12	625.7		
Winthrop	Extension easterly	18	110 4	1	483 20
Stone	Ward Street to Perry Avenue	15	328.6	5	1276 74
Perry Ave	Stone Street to Harlem Street	15	31.2	4	
		12	366 2		
Vernon	Maxwell Street northerly	12	848.9	9	1390 84
		10	440 0		
Perry	Millbury Street westerly	12	880.5	7	945 71
Millbury	Lafayette Street southerly	12	108.2	2	174 09
Sigel	Quinsigamond Ave. to Bigelow Street.	15 oval	334.3	5	566 45
		12	304 8		
Riley	Kansas Street to D Street	12	320 3	2	277 16
D	Lawrence Street to Colton Street	12	100.9	2	222 42
Colton	D Street westerly	12	132.0	2	
Camp	Cambridge Street to Southgate Street	12	807.9	7	971 44
Hacker	Cambridge Street to Southgate Street	15 oval	201.9	7	1879 28
		12	488.9		
Southgate	Hacker Street southerly	12	581.3	5	
Litchfield	Hacker Street westerly	12	839 5	7	868 59
Cheever	Chelsea Street to Woodward Street	12	566.8	5	445 13
Fremont	Extension to Sutton Lane	30 x 45	251.8	1	19096 65
Sutton Lane	Fremont Street to Cambridge Street	30 x 45	538.9		
Cambridge	Sutton Lane to Webster Square	28 x 42	1566.0	6	
Main	Webster Square to Lowell Street	12	739.0	12	1376 01
		10	705.8		
Albert	Grand Street southerly	12	230.9	2	316 93
Birch	Maywood Street to Oliver Street	12	541.3	5	890 93
Florence	Maywood Street to Shirley Street	12	392 1	3	344 84
Woodland	Norwood Street to Oberlin Street	12	158.2	2	442 64
Mason	Parker Street to Bluff Street	21 oval	408 6	3	1020 19
	Bluff Street Curve	21 oval	27.3	1	
Cedar	Extension to Agricultural Street	8	103.2		253 62
Agricultural	Cedar Street northerly	8	518 2	2	
Highland	Sever Street easterly	12	355.3	3	534 34
Highland	West Street westerly	12	165.6	1	133 05
Millbrook	Lafayette Street to Endicott Street	Arch	547 3		10027 28

There are now 76.59 miles of sewers, including the outfall sewer, 2910 manholes, and 1594 catch basins, an increase of

4.25 miles of sewer, 174 manholes and 65 catch-basins during the year.

Work on the purification plant was continued during the winter, and the tanks completed as far as was possible, so that when chemical precipitation was definitely adopted as the method of purification, little remained to be done except to erect suitable buildings, procure and place such machinery as was necessary, and connect the outfall sewer with the sewer system of the city.

There were many delays and much unforeseen difficulty in procuring and setting the machinery, but sufficient progress had been made by June 25th, that on that date the sewage was turned into the outfall sewer and through the works, and purification was begun, and within the limit of time prescribed by statute.

Much remained to be done, however, to render the works complete, and a large force has been employed on them during the season. A large tract of land lying between the N. Y., P. & B. R. R. and the Blackstone River has been purchased, a portion of it cleared and graded and laid out into sludge beds. More of these must be prepared, as those now in use are overtaxed to accommodate the refuse from the precipitation tanks. An arrangement was made with the N. Y., P. & B. R. R. whereby a spur track was constructed to the works, so that coal and chemicals are now unloaded from the cars directly into the storage bins, making a very complete and effective system of handling supplies.

A building containing rooms for office and laboratory has been built, and the office furnished, and it is intended to soon furnish the laboratory in such a manner that crude analyses can be made and tests applied, showing more accurately than can now be done the action of the several chemicals on the sewage treated.

The works are run continuously day and night, and require the closest supervision and care, as the constantly changing sewage requires a constantly varying treatment to obtain the best and most economical results.

It was deemed advisable to employ a Civil Engineer to take direct charge of the works, and an assistant from the City Engineer's office who had been intimately connected with the construction of the works was secured. The wisdom of this course is shown in the most gratifying results attending the work.

The only drawback to the complete success of the purification system is the inability to care for the entire flow of the stream as now constituted. This can only be remedied by separating the water of mill brook from the sewage proper, a work of considerable magnitude, but one demanding immediate attention.

The tools and machinery of the Department are in excellent condition, and include appliances for nearly all varieties of work liable to arise.

An express team was purchased early in the season, and has proved a very profitable investment, as it is able to do a very large amount of work formerly hired done, and much more cheaply than under the old method. The horse is kept at the stable of the Highway Department, and cared for by its driver

The suggestion contained in the last annual report, relative to the employment of a clerk, is now renewed, and it is hoped will receive your careful consideration.

Respectfully submitted,

RICHARD FOBES,

Supt. of Sewers.

REPORT OF THE CITY ENGINEER TO T COMMITTEE ON SEWERS.

To the Joint Standing Committee on Sewers:

I beg leave to submit the following report for your con tion:

The work of extending the main outlet sewer to the larg rapidly growing district around Britton square and the no ly end of Lincoln street has been continued. A point has reached where it will be necessary to decide upon a locatio tween the northerly end of Crescent street and Lincoln s before work can be resumed. The plan that I have sugge and which I think it will be advisable to follow, is to lay o street principally through land of E. P. Curtis, having easterly terminus at Lincoln street, nearly opposite Washin avenue, and in this street to construct the sewer. This is most direct route, and as Mr. Curtis offers to give the land, I think, the cheapest. The other route is known as the Vi street route; and, while it would have the advantage of foll ing a street already constructed for a greater portion of the d tance, the line would be longer and work so much heavier, t the cost of construction would more than balance the advant that would otherwise be derived from constructing the sewer a street already laid out.

The New Worcester district should receive further attentio The main outfall in Cambridge street, Sutton lane and Fr mont street has been completed, and a lateral sewer construct in Main street between Webster square and Lowell street.

There are several petitions for surface water sewers in thi

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district, some of which are needed and should be constructed at once.

As stated in the reports of previous years, the outfall sewer constructed to carry the sewage to the disposal works is also intended to be the main sewer of the Quinsigamond district. I can see no reason why sewers cannot now be constructed at any time in any of the streets of the district. A sewer has been ordered in Perry street and is now in process of construction. It is the only sewer so far constructed for sewage purposes in this locality.

In this connection I desire to again call your attention to the fact, that the plans of this and the New Worcester district call for the construction of sewers by what is known as the "separate" system, *i. e.*, small pipe sewers are to be laid for the purpose of caring for sewage proper, and larger sewers of pipe or brick, as the case may be, are to be constructed for the purpose of caring for surface or storm water.

As it is probable that a large number of sewers will be constructed in the above localities in the next three or four years, I most earnestly urge that rules governing the manner in which they are to be used, may be adopted at an early day. I feel that it is absolutely necessary that the use of these sewers shall be so regulated that nothing but sewage from buildings should be discharged through them into the outfall sewer.

The question of disposal is very much complicated by the presence of storm water in the old system, and I am very desirous to eliminate as much as possible this objectionable feature in sewers that are constructed in the future.

SEWAGE DISPOSAL.

Since writing my last report the sewage disposal works have been practically completed. The buildings are finished, the machinery is in operation, and the work of sewage disposal is well under way, and I am firmly convinced that the result will be entirely satisfactory, after all the sewage of the city is brought to the works for treatment. Considerable improvement has been noted in the condition of the river already. It is a matter of frequent occurrence for people living near the stream below the city, to state to us that it has been in much better [illegible] raised [illegible] a section [illegible] had been removed [illegible] was [illegible] of [illegible] excavation. This [illegible] consist of [illegible] and was removed at a comparatively [illegible]

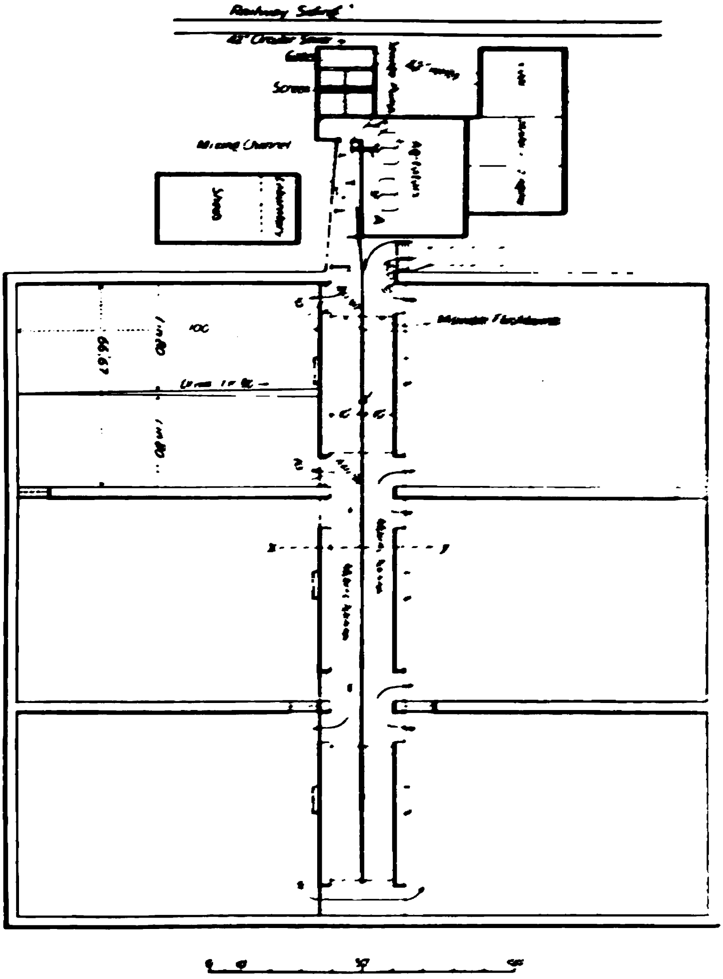
[illegible] had been excavated [illegible] previously [illegible] filled [illegible] with water. This took [illegible] the level of the ground water is nearly [illegible] of the stream. [illegible] was then begun. The [illegible] consisted [illegible] buildings and almost the entire [illegible] and [illegible] gravel [illegible]. This was first [illegible] and the gravel dumped into the water filled excavation [illegible] constantly [illegible] being taken to distribute the material as evenly as possible so as to [illegible] settlement. After the filling had reached the level of the water surface the remainder was put on in thin layers, and in addition to being compacted by the [illegible] carts running over it was thoroughly rolled with a five-ton grooved roller. The result [illegible] compact bank, which, so far as we have been able to see, has never settled in the least.

The next work was the construction of the tanks, a ground plan of which is shown in Fig. 2. As foundation for the walls [illegible] and 5 [illegible] Rosendale cement concrete 12" thick and [illegible] wider than the walls, was first laid. This concrete was composed of three parts screened gravel, two parts sand, and one part cement. Upon this foundation the walls were laid in the following manner:

First, a rubble wall of small stones carefully laid in cement mortar was erected. In the division walls this is about 26" thick, while in the side walls it is 26" at the bottom and 16" at the top, having a batter on the back side. (See Fig. 5).

This wall was left very rough on each face so as to insure a good bond with the brick facing, which is 8 inches in thickness. The bricks were carefully laid in cement mortar, great care was taken to insure getting a perfect bond with the stone work.

The brick used were selected New Hampshire brick. The coping was formed of quarry chips and Portland cement in the following manner: First a wooden mould was clamped to the top of the wall. This was loosely filled with the quarry chips,


Railway Siding
Gate
Screen
Mixing Channel
Agitators
66.67
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100
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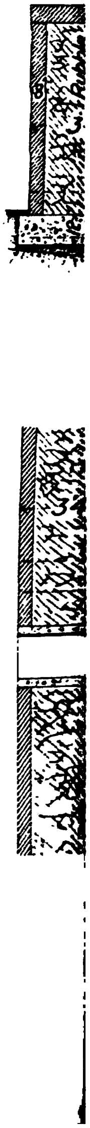
Main Carrier
0 10 50 100



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and the whole thoroughly grouted with Portland cement mortar. This form of construction has in this case proved eminently satisfactory. The coping is, apparently, as hard as granite; and, in many respects, is much more satisfactory. The walls are absolutely water-tight.

After the walls were finished the work of concreting the bottom of the tanks was begun. This concrete is made of Rosendale cement, sand and gravel, the proportions being the same as used in the wall foundations. This work was principally done in the winter of 1889 and '90; and to prevent freezing a temporary roof was laid over the tanks, and a steam pipe connected with the boiler of one of the hoisting engines was run through the center of each tank. By this means the temperature was not allowed to fall below 40° Fahrenheit.

As fast as the concrete was laid it was covered with tar paper and sand to prevent its becoming washed while green, by water dripping from the roof which was not made absolutely water-tight. This concrete floor averages 12″ in thickness. It slopes from each side toward the centre with a fall of one in eighty, and has a central drain, or trough, which also has a slope of one foot in eighty feet from the outside end wall to the central channel (see Fig. 2).

There are six tanks, each being 100 feet long—66.67 feet wide and 7 feet deep. When full and in operation there is five feet in depth of sewage.

The central channel, including the pipe arch, was then constructed (see Fig. 3). The side walls of the arch are of stone laid in cement mortar, 26″ in thickness. The arch is of three courses of brick and the foundations are of cement mortar. In this arch is laid the 18″ effluent pipe, and also the main sludge drain. The pipe (Akron) is entirely surrounded with Portland cement mortar to insure its being absolutely water-tight.

Opposite the centre of each tank is a side arch extending to the end walls of the tanks. In these are laid the pipe for emptying the tanks, and also the drain connecting the main sludge drain with the drain in the tanks, so that every foot of pipe and drain can be easily examined except where they pass through the walls.

The upper dotted lines in Fig. 3 show the side pipe connections, and the lower dotted line the grade of the side sludge drains.

Fig. 4 is a ground plan of the same thing. The main sludge drain is connected with the sludge well located in the basement of the machinery building, at point A, Fig. 2.

This well is 10 feet in diameter and 8 feet deep. The excavation was entirely in quicksand. The well is constructed of brick, laid in Portland cement.

The next thing in order was the construction of the main channel, used to conduct the sewage to the tanks. The space between the side walls of the arched chamber and the end walls of the tanks was first filled with puddled or packed gravel. Upon this was placed 8 inches of Portland cement concrete, finished to a very smooth surface on top. This forms the floor of the channel. This channel is divided in the middle, except at its lower end, by a wall of brick work, 12" thick, which is surmounted by a coping of Portland cement concrete.

In general section, each channel is 10 feet wide and two feet deep (see Figs. 2 and 3). The grade of this channel is very slight, except where it passes tank No. 1, the elevation at the outlet of tank No. 1 being 420.90, while the elevation at the point where the effluent is discharged from tank No. 6 is 420.72. The fall in passing tank No. 1 is one foot, and there is a drop of one foot from the channel at the first weir to the surface of the sewage in the tank, when filled. The tanks are so arranged that they can be used separately or altogether, the flow to and from each being regulated by flash boards at the weirs (see Fig. 2).

The walls of the gate and screen chamber are constructed of brick, laid in cement mortar.

The mouth of the outfall sewer is at the upper end of this chamber. It is divided by partition walls into four sections,—first, the receiving chamber, which is 18 feet long and 6 feet wide; second, two screen chambers, each 15 feet long and 8.5 feet wide, so arranged that while one is being cleaned the other is in use; and third, the outlet chamber which is 18 feet wide at upper end and 3½ feet wide at lower end, and is 7 feet long, (see Fig. 2).

The gates controlling the flow of the sewage are of wood, an ordinary rack and pinion hoisting apparatus being used. The screens are made of flat bars of iron with ½ ′ spaces between.

The mixing channel extends from the lower end of the screen chamber to the inlet weir of the first tank. The walls are of brick, laid in cement mortar, and capped with a coping of Portland cement concrete. The bottom or floor is also of Portland cement concrete. There are five baffle plates of wood projecting into this channel (see Fig. 2), so arranged as to break the flow of the sewage and to agitate it sufficiently to thoroughly mix the chemicals with it. This mixing channel, which is 46.4 feet long, has a fall of 9 inches.

The overflow steps and the effluent drain, shown in Figs. 6, 7 and 8, together with the 42″ waste drain, were the last pieces of masonry to be constructed. The steps are of granite, cut faces, and rest upon a foundation of rubble masonry laid in cement.

Under the steps is the culvert into which the effluent pipe discharges, and which conducts the water from the pipe to the effluent drain (see Figs. 6 and 8).

The space between the bottom of the steps and the mouth of the effluent drain is paved with selected granite street blocks, laid in Portland cement and mortar. Effluent and waste drains are constructed of brick, 8 inch rings, the waste drain being circular in shape, while the effluent drain is of the shape shown in Fig. 7. The two join at the northeast corner of Tank No. 6, from this point discharging into the river through a common channel (see Fig. 2). The tanks cost $40,000, which is exactly the estimated cost.

The buildings are all of wood, and consist of an engine house, boiler house, machinery building, coal sheds, gate and screen house and laboratory with sheds attached. The different buildings are of the following dimensions: Engine house 16.5′x32′; boiler house 15.75′x32′; coal sheds 24x24′; machinery house 35x 40′; gate house 20x32′; laboratory and sheds 23x47′; there is also a small lime shed 11x24′.

The power is supplied by a 60 horse-power Brown engine. This was purchased second-hand, but had been run very little. The boiler was supplied by Stewart & Son, of Worcester. All of the rest of the machinery by Holmes & Blanchard of Boston, Mass.

On the first floor of the machinery building are the agitators and vats for mixing the chemicals with water, preparatory to discharging them into the sewage. The vats are elliptical in shape, 5x8′, and are 7 feet deep. Two of the vats are for lime mixing and two for sulphate of alumina.

In each vat are two perpendicular shafts with horizontal arms. These shafts are geared to the main shaft overhead. These are for mixing together the chemicals and water. On this floor is also located the well into which crude sewage is run to supply water for mixing purposes. This sewage is pumped by a four-inch centrifugal pump into a tank on the second floor. The necessary amount of water required to do the mixing in the vats being drawn from it as needed. In the basement (A Fig. 2) is the sludge well, as before stated, and a six inch centrifugal pump for pumping the sludge. The second floor is used for a chemical room, the lime and alumina being stored here. On this floor is also the crusher for pulverizing the lime, the scales for weighing the chemicals, and suspended from the floor above is the hopper into which the crushed lime is discharged after being sifted. The sifting is done by a revolving screen located on the third or upper floor. The coarser particles are discharged into a wooden trough which conducts them to the floor below where they are re-ground. The crushed lime is carried from the crusher to the screen by means of buckets on an endless belt similar to those used in grain elevators. Since operations were begun on the 25th of June, the amount of sewage treated daily has averaged 3,000,000 gallons.

As previously stated, Mill Brook is intercepted by the outfall sewer near the Washburn & Moen Wire Works on Millbury St., the flow being regulated by a gate in the gate house located at this point. It is not the intention to be absolutely exact as to the amount that passes through this gate, but it is kept open sufficiently to allow at least 3,000,000 gallons per day to pass through. If five million gallons pass through, two million gallons are turned into the waste drain at the works and pass off into the river, it making no difference of course whether it gets into the river at this point, or passes off with the brook at the mouth of the main sewer. This method will have to be followed until the separating system is constructed.

The treatment which we have finally adopted is the "continuous process." The sewage, after leaving the outfall sewer, enters the receiving chamber in the gate or screen house. It then passes through the screens, where all matter that would tend to clog the sludge pump are screened out, such as paper and sticks of wood. It then passes through the outlet chamber into the mixing channel. The chemicals are introduced at the upper end of this channel, being discharged through pipe connected with the vats inside the building. After the introduction of the chemicals the sewage flows through the mixing channel, the chemicals being thoroughly mixed with it by the agitation produced by the baffle plates. From this channel the sewage passes through the first wier into tank No. 1. Here there is a fall of one foot which tends to more thoroughly mix together the sewage and chemicals, it then passes very slowly through tank 1, out of this tank through the second weir into the main channel, then through the third weir into tank 2, through tank 2 into tank 3, and thence through tanks 4, 5 and 6, until it is discharged finally through the last weir and over the overflow steps into the effluent drain, and from thence into the river; it takes about six hours for it to pass through all the tanks. The position of the wiers, and the general arrangement of the tanks is shown by Fig. 2.

When it becomes necessary to clean a tank, the flash-boards are placed in the wiers connected with this tank, and the sewage is passed around into the next tank through the main channel. Tank No. 2, in Fig. No. 2 is represented as being cut out. The sewage in the tank to be cleaned is then allowed to rest from three to six hours, so that thorough precipitation will take place before the water is drawn off.

In front of each effluent pipe, and projecting into the tank is a flume of wood. This flume is so constructed that the water can be drawn from the surface by means of flash-boards 6 inches deep. When the time has arrived for drawing the water, the first flash-board is removed and the gate at the mouth of the effluent pipe is opened. The water flows over the top of the second flash board through the gate and effluent pipe into the effluent drain and then into the river. This method is repeated until all the boards have been removed and the water drawn down to the level of the sludge. The gate at the mouth of the sludge drain is then opened and the sludge flows through the sludge drains to the sludge well under the building. It is pumped from this well into a pipe carrier, and flows by gravity to the sludge beds located on land owned by the city, situated on the easterly side of the Providence & Worcester Railroad, and entirely removed from the works. This land (about 16.5 acres) was selected for this purpose owing to its very favorable location. It is situated between the railroad and the river, is entirely isolated, there being no way to reach it except through land ownded by the city. The liability of complaint being made by reason of its near proximity to buildings is thus reduced to the minimum. A little over one-half of the area is low, swampy land; the remainder is covered with knolls of gravel.

At present 11 sludge beds are in use, all being located on the low land. They are formed by removing the turf from the surface and constructing dykes with the soil removed. The beds are rectangular in shape, and are about 100 feet square. One day's sludge is pumped into each bed. It is then allowed to rest for 11 days, the second bed receiving the sludge the next day, and so on through the series. This is done to avoid any possible chance of a nuisance arising from any one bed being overcharged. Occasionally a layer of gravel is spread over the accumulated sludge. In this way it is intended to grade the surface of the entire area, after which it is intended to erect a destructor upon the land and burn the sludge,—which, from experiments that have been made, I am convinced can be easily done. These beds have been in almost constant use since the works were put in operation, and there has never been the least trace of bad odor arising from them even during the hot summer months. This is, without doubt, due not only to the care that has been used in not allowing them to be overcharged, but also to the character of the sewage, and therefore to the character of the sludge, it being heavily charged with iron, salts and lime. Everything that would tend to create a nuisance seems to be entirely killed out.

The precipitation takes place principally in the first three tanks. The sludge has to be removed from tanks Nos. 1 and 2 about once in 36 hours in warm weather, but during cold weather we have been able to go four days without cleaning, without perceptibly affecting the character of the effluent. Tank No. 3 is cleaned every two or three days in warm weather, and once in 7 or 8 days in cold weather. Tanks 4, 5 and 6 accumulate very little sludge; but they are cleaned as often as is necessary,—about once a week in the hottest weather and once in three weeks during the colder period. In the first two tanks during warm weather, or when the sludge is removed once in 36 hours, the accumulation is about 10 inches deep over the entire bottom surface. No. 3, when cleaned once in three days has a depth of sludge of about 8 inches. Nos. 4, 5 and 6 when cleaned once a week, have an accumulation of about 6 inches. The sludge is about 95 per cent. water; and after it has been spread upon the sludge beds for about 9 days this almost entirely disappears. The precipitant principally used at the works is Vermont lime. This has proved to be much better for our use than either eastern or western lime. It costs, delivered at the works, about $7.00 per ton. The sulphate of alumina, which is used in limited quantities, costs about $25.00 per ton delivered.

The sewage is extremely acid, owing to the fact that large quantities of sulphuric and muriatic acids are discharged into the sewers from iron manufacturing establishments. This acid does not appear at the works in uniform quantities, but is extremely intermittent. It generally makes its appearance once in about 6 hours, although there is always acid present in the sewage. The heavy flow of acid sewage generally lasts about one and one-half hours.

In order to get perfect precipitation and a good effluent, we have found that it is necessary to neutralize this acid, or in other words, to make the sewage alkaline. This is done by introducing a sufficient quantity of lime to accomplish the object. It is therefore necessary to test the sewage at very frequent intervals during the 24 hours. Samples of the sewage are taken in glass beakers after the chemicals are introduced and the test is made in the laboratory. As a test for alkalinity, phenolphthalein is used. A very small quantity is dropped into the beaker of sewage, and if the liquid turns red the sewage has been made alkaline by the lime; if the color remains unchanged more lime must be introduced.

The sulphate of alumina is used with the lime on occasion when there is not sufficient iron salts in the sewage, to act with the lime in producing a good effluent, generally Sundays and Mondays. The quantity of lime used varies with the varying character of the sewage. We have found by experience, that there is no fixed rule that can be followed. The number of grains per gallon varies from one, to two hundred of lime, and from one, to forty of alumina. The larger amounts are for short intervals of time, so that the average for 24 hours rarely exceeds 8 grains of lime and 4 of alumina per gallon.

When operations were first begun the tanks were used intermittently, and a fixed amount of lime per gallon was used, that is, 15 grains, say, of lime per gallon was used without regard to the character of the sewage, as is the practice in many of the European works. It was soon found that while at times the effluent would be very fine, at other times it would be very poor. And we soon found that in order to obtain a uniformly good effluent the quantities of lime or alumina had to be increased or diminished, as the character of the sewage varied, so the series of tests previously spoken of, were resorted to and have been constantly adhered to since, with the result of obtaining an effluent of remarkably uniform character.

After we were satisfied that we had discovered the correct principle of applying and mixing the chemicals, the tanks were used continuously, *i. e.* the sewage was allowed to run through the entire series, as at present, and this plan has been followed ever since.

At first, there were days at a time when as high as 4 tons of lime was used, and very much larger quantities of alumina than at present. Experiments without number were made to see if this excessive use of chemicals could not be reduced, and finally the following plan, which has been extremely satisfactory, was hit upon.

The arrival of the acid sewage at the works is anticipated, and preparations are made so that when it arrives it is thoroughly treated with lime, making it alkaline. As this flow generally lasts an hour and a half at a time, tanks 1 and 2 become heavily charged with it. After this extremely acid sewage has passed into the tanks, the machinery is stopped, and no more chemicals are added until the arrival of the next dose of acid in large quantities,—generally from four to five hours.

During this interval of time, the sewage that passes by the works and into the tanks is so thoroughly treated by the iron salts and lime present in the extremely acid sewage that has just preceded it, that the effluent is as good, if not better, than it would be if chemicals were applied as it passed the works. In other words, there is an excess of chemical matter in the acid sewage after the lime is added, which is utilized as a precipitant, by passing crude sewage through the tanks heavily charged with it. Experience has demonstrated that crude sewage passed through tanks 1 and 2 previously filled with the acid sewage, will become mixed with it, and that this can be relied upon to do its work thoroughly for intervals of from 4 to 5 hours. This has resulted in the saving of large quantities of lime, the amount now used per day being about one-half the amount used for sometime after the works were put in operation.

All the lime and alumina used is weighed in the chemical room before it is turned into the vats. In this way the number of grains per gallon is determined.

I have already described the manner in which the sewage is tested, the object being to have it alkaline when it enters the tanks. If it is necessary to increase or diminish the quantity of chemicals used, the person making the tests gives the order through a speaking tube connecting the laboratory with the chemical room. All orders are given in grains per gallon. For instance, if it is desired to use 10 grains of lime per gallon 12 lbs. of lime is poured into the vats once in 4 minutes. If it is necessary to increase to 20 grains per gallon, 23.75 lbs. is used every 4 minutes; thirty grains calls for 26.75 lbs. every 3 minutes; fifty grains calls for 44.75 lbs. every 3 minutes; 100 grains, 89 lbs. every 3 minutes; 150 grains, 89 lbs. every 2 minutes; 200 grains, 119 lbs. every two minutes; 300 grains, 89 lbs. once a minute. The above is on a basis of 3,000,000 gallons in 24 hours. Tables have been prepared, and are kept in the chemical room in a conspicuous place so that the operative there can tell at a glance the number of pounds of lime or alumina he is to put into the vats, in response to the order from the laboratory.

It is not my purpose in this report to give the result of analy-

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It is not my purpose in this report to give the result of analyof the invert in the old sewer are very badly out of repair, and more or less solid matter will be deposited at such points. This extra amount of water will be taken to the works and treated before it is turned into the river.

In this connection I desire to call your attention to the fact that wherever the invert has been reconstructed of concrete there has been no deposit, and not a dollar for cleaning at these points has been expended.

We have one section of 4,000 feet that has been in use nine years. Every particle of the sewage of the city has passed through it in that time, and no cleaning has been done; there is absolutely no deposit.

In time the entire invert will have to be reconstructed in a similar manner, but there need be no great hurry about it. I should say, however, that, as a matter of economy, a portion should be done each year. When this is finished, there will be no further need of cleaning the channel.

The excess of water during storms in the lateral sewers will escape over a storm overflow at the lower end of the present main sewer. By this plan all the sewage of the city can be treated except during freshets, and then it will be so diluted with storm water that no possible harm will be done if a portion of it escapes into the river.

In case intercepting sewers were constructed, a storm overflow would have to be provided at the mouth of each lateral sewer so that the effect would be exactly the same, so far as polluting the river is concerned.

In my opinion the plan proposed is simpler, cheaper, and will do the work fully as well as any other that has been suggested.

In closing, I desire to thank the committee for the uniform courtesy and kindness with which they have always treated me, and for the great help that their cordial support has always been in solving the difficult problems that have had to be considered.

I also wish to express my great satisfaction with the manner in which Mr. McClure, the Assistant Engineer, and other assistants have performed their duties.

Respectfully submitted,

CHARLES A. ALLEN,
City Engineer.

WORCESTER, Dec. 29th, 1890.

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ANNUAL REPORTS

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OF THE

COMMITTEE ON SEWERS,

THE

SUPERINTENDENT OF SEWERS,

AND THE

CITY ENGINEER

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1891.

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REPORT OF THE JOINT STANDING COMMITTEE ON SEWERS.

The Joint Standing Committee on Sewers herewith submits its report for the year ending Nov. 30th, 1891, accompanied by the reports of the Superintendent of Sewers and the City Engineer.

At the beginning of the year the system of sewerage contained 76.59 miles. There has been added to this during the present season .95 miles of trunk sewers and 3.40 miles of lateral sewers, total 4.35 miles,—making the total of the entire system at the present time 80.94 miles.

Special attention has been given to extending the system known as the "Hermitage Brook" system and in the Adams Square district. The trunk sewer in Shrewsbury street has also been extended to the grounds of the State Lunatic Asylum. The settling of the land in what is known as the "Island District" made it imperative to reconstruct the Bradley street sewer. The details connected with each of these will be found in Superintendent McClure's report.

Attention has also been given to the arching of Mill Brook Sewer from the northern line of Crompton Park through the Park at an expense of $9,320.30. A large number of petitions have been presented and attention has been given to as many localities as it has been possible to serve with the amount of money at the disposal of the committee. Much more needs to be done in the extension of both main and lateral lines. There are now sections of the city where the committee would have been pleased to have put in sewers which are very much needed, especially in the Belmont street and Hermitage Brook localities.

The general condition of the sewers of the city is excellent.

The policy has been to do whatever was done thoroughly and substantially.

The total expense for the year has been as follows:—

For Construction,	$62,457 14
For Arching Mill Brook,	9,320 30
Purification Works,	27,761 95
Maintenance,	14,385 02
	$113,924 41

An item of interest in the cost of maintenance deserves notice here. With over four miles of line more than last year the cost this season has been $14,385.02 as against $14,731.38—a saving of more than $350. This has been due largely to the dry season which has worked advantageously so far as the sewerage is concerned. The cost for maintenance next year, with over eighty miles to care for, and considering the fact that the outfall sewer must be cleaned and the probability that the weather will not be as favorable as this season, will add considerably to the expense in this direction.

The Purification Works at Quinsigamond have attracted the attention of many citizens and a large number of people from outside the city who are interested in the very important question of sewage disposal, and while there is yet very much to be done and difficult problems to be solved, your committee feels that no mistake has been made and that the money thus far expended has been along the line which promises ultimate success. The work accomplished, while only partial as compared with what remains to be done, is highly satisfactory, and all that could be fairly required of the city in the short time intervening has been accomplished. Your committee is of the opinion that the work upon the present plan should be increased. Sewage can and is being practically treated by chemical precipitation.

The two important factors are—the quantity to be treated, and the disposal of what is called sludge.

In order to treat the entire flow, the waters coming down from above the city should be separated, as has been suggested in several reports. It will also be necessary probably to build four new tanks.

With these two important changes made, the present flow could undoubtedly be cared for in a manner which would give entire satisfaction. The problem then would be the disposal of the sludge. During the year a new furnace has been erected for burning this with quite satisfactory results. For more detail with reference to these questions we refer you to the reports of the City Engineer and Superintendent of Sewers.

In the early spring the city lost in the death of Mr. Richard Fobes a faithful, efficient officer, a man who had made a careful study of his chosen profession and was becoming more and more valuable each year to the city. As an officer, Mr. Fobes was quick, clear-headed and a pleasant man to be associated with. As an employer of men, he was just, firm, efficient, beloved by all. As a friend, he was social, genial and is greatly missed.

On March 17th, 1891, the City Council elected Mr. Fred A. McClure to fill the vacancy caused by the death of Mr. Fobes. The members of the committee are pleased to make mention of the thorough manner in which Mr. McClure has taken up this work and of their very pleasant associations with him and with the City Engineer.

We believe that ultimate success will crown the efforts of the city in this matter of sewage disposal, and that these two officers will contribute largely to this desired result.

FRANCIS A. HARRINGTON,
FRANCIS PLUNKETT,
GEO. C. WHITNEY,
ROCKWOOD HOAR,
GEO. S. DIXON,
ALEXANDER BELISLE, Jr.,
F. A. ATHERTON.

Joint Standing Committee on Sewers.

REPORT OF THE SUPERINTENDENT OF SEWERS.

To the Joint Standing Committee on Sewers:

GENTLEMEN :—I respectfully submit the following report:

The work of this department, with which you have been intimately associated, has actively progressed throughout the season, and substantial gains to the sewerage system in the several districts have been made. One year ago this month, work was begun upon the Richland street sewer, which was brought to a successful termination in the early spring. The nature of this work required excessive excavations in ledge, which permitted its construction during the winter months. It has been a noticeable fact that this material has developed to an unusual extent during the season's work, adding largely to the expense; a feature discernable, with one exception, on every trunk sewer constructed. The main sewer for the Adams Square district has been extended from Crescent street to the Square, with laterals in Lincoln street and Washington avenue, affording partial relief to this populous-growing vicinity. Other additions are greatly needed in this district, and require consideration. The sewer through the valley of the Hermitage Brook has been extended to Catharine street, from which point the pressing needs of the near locality can be readily relieved. The Bradley street sewer, with the laterals in Gold street court, which was found to be in such a defective state as to be nearly useless, has been reconstructed. The underlying material through which this sewer passes, is a soft mud of such an unstable nature that the entire vicinity seems to have settled and carried the sewer with it. The reconstructed sewer is built upon piles, the driving of which in one place was carried down to the depth of seventy feet before bottom was found. During construction these piles were placed longitudinally four feet apart, and were capped with two timbers 6x6 inches square thoroughly spiked down. Upon the top of these timbers, the pipe was laid and confined by gravel solidly tamped.

Expensive sewers have also been built in Shrewsbury, Vernon, Grafton and East Kendall streets. Another section of Mill Brook has been arched, extending from Endicott street to the southerly line of Crompton Park. The New Worcester district received attention early in the season, several laterals being built in this system besides the construction of sewers in Lake and Cambridge streets for the relief from surface water. In connection with this district and also others that are being constructed on the principle known as the "separate system," I desire particularly to call your attention. Many of these sewers that are designed wholly as sewage carriers, are often utilized to convey large quantities of surface water, through the house connections. This feature being foreign to the purposes for which they are built, and the results in a measure antagonizing the efforts at purification, it is of the utmost importance that measures should be taken regulating their use.

The following table shows the size, length, cost and location of all the sewers built by the Department during the year:

Table of Sewers Constructed during Financial Year of 1891.

Street.	Location.	Size. (Inches.)	Length. (Feet.)	Manholes.	Cost.
Rodding Court ..	Prescott Street easterly..............	12	218.3	3	$347.00
Harlow	Crescent Street to Lincoln..........	36 x 54 26 x 39	284.1 1013.7	9	6260 84
Lincoln..	Green Lane to Brittan Square......	26 x 39 24 x 36 15 oval 15 12	37.5 1068.0 225.3 322.6 173.8	16	5965.07
Washington Ave.	Lincoln Street to Uxbridge....	18 x 27 15 12	330.4 310.4 268.2	7	1925.86
Ashton	Washington Ave. southerly	15 oval	334.0	4	527.75
Hermitage Brook	Kendall Street to Catharine...........	36 x 54	550.0	5	3038.55
East Kendall	Eastern Ave. to Rodney Street........	12	386.3	4	1204.28
Rodney..........	East Kendall Street southerly........	12	112.0	2	
Seward	Shrewsbury Street to Wilson..........	15	255.5	3	397.77
Marshall.........	Shrewsbury Street to Wilson..........	15	263.7	3	397.44
Shrewsbury	Putnam Lane to State Lunatic Hospital Land.......................	32 x 48 30 x 45 20 x 30	323.6 956.7 768.9	16	9965.94
Grafton..........	Houghton Street to Hale............	18 15 oval	498.9 351.9	7	1517.47
Water	Fox Street northerly..................	12	161.7	1	268.71
Bradley and	Gold Street to Washington..........	18 12	441.2 306.8	8	4706.99
Gold St. Court...	Assonet Street to Lamartine	15 oval 12	380.0 233.0	6	
Mill Brook.......	Endicott St. to s'th line Crompton P'k	....	472.7	......	9320.30
Richland	Ward Street to Vernon................	12	675.6	5	2058.74
Vernon	Woodside Street southerly..........,	18 x 27 12	612.1 583.1	10	3056.76
Surface Sewer	Washburn & Moen M'f'g Co. yard....	24 x 36	39.5	......	110.65
Tatman	Outfall Ave. westerly..................	12	906.5	7	899.80
Kansas	Cambridge Street to Sherman.........	15	326.0	3	363.86
Pitt	Cambridge Street to Sherman.........	18	359 0	3	757.69
Colton	Washburn Street to Southbridge......	12	382.7	4	546.36
Riverside	Southbridge Street easterly...	12	238.5	3	324.77
Lewis.......	Southbridge Street to Princeton.......	12	871.8	8	884.30
Carson Court....	Grand Street easterly.................	12	188.0	2	423.49
King Court	Southgate Street northerly............	12	127.4	2	203.59
Southgate	Hacker Street easterly................	12	170.3	2	207.66
Surface Sewer...	Canterbury St. to Knowles Loom W'ks	12	267.4	2	76.70
Tainter	Ripley Street to Hammond...........	12	719.3	6	931.44
Cambridge	Webster Square easterly..............	12	206.2	3	179.88
Agawam.........	Main Street northerly................	8	347.6	8	340.52
Tirrell	Main Street southerly................	8	1042.5	7	933.42
Lowell...........	Main Street to Freeland..............	9	681.6	6	526.27
Lake Surface Sewer.... ...	Leicester Street to Sutton...........	15 15 oval 12	498.1 557.6 303.6	11	1750.15
Park Ave........	Maywood Street to Oliver............	18	580.5	5	1679.58
Downing	Park Ave. southerly..................	15	337.2	2	481.34
Parker	Park Ave. to Bradford Street.......	24 oval 12	273.1 207.7	3	740.85
Winfield	Parker Street southerly...............	12	301.6	3	314.47
Queen	King Street easterly..................	12	130.7	2	265.65

The system now comprises 80.94 miles of sewers, 3118 manholes and 1667 catch-basins; an increase during the year of 4.35 miles of sewers, 212 manholes, and 73 catch-basins. The number of permits issued to connect with the public sewers is 542.

The season has been an unusually favorable one for the work of maintenance; the absence of heavy rains reducing the usual amount of wash that enters the sewers and materially decreasing the cost of catch-basin work, conditions that are responsible for the favorable exhibit of expenditures.

To dispose of the large accumulations collected from this source, is a question that is becoming serious; and as the former dumping-grounds are prohibited for this purpose, the necessarily long hauls to a suitable place of deposit, largely increase the cost. It is believed that it would be a source of economy, if much of this material was gathered from the streets before reaching the semi-fluid condition in the basins. During the year there have been 4 catch-basins rebuilt, and repairs made on 95 basins and 116 manholes, besides the numerous alterations made necessary by street work. At the beginning of the year, in the entire system there remained 115 wooden catch-basin covers, and in continuation of previous policy, these have been replaced by iron ones, thus completing this work and eliminating this feature of former expense.

There also have been improvements made of a character greatly needed, at the department headquarters, on East Worcester street. An engine-house sufficiently large to hold the several engines has been built, which has proved a relief to the cramped quarters of the main building and simplified the loading and handling of these machines. The yard in front of this building has been paved with cobbles collected from work in the vicinity. A new blacksmith-shop of enlarged dimensions has been added, which permits of work being done that the old shop did not admit of.

The work of sewage purification has been constant; and while the difficulties have been many, a considerable gain in the prosecution of the work has been made. On the 19th of June, the treatment was increased to six million gallons in 24 hours, and although this amount is considerably in excess of the capacity of the plant, yet it was thought to be more beneficial to the river than the result would be from a smaller amount more thoroughly precipitated. There has been treated during the year, 1,399 million gallons of sewage; and from this amount there has been precipitated 22.042 million gallons of sludge, which has been pumped into the pits prepared for it. Of this amount of sludge, the proportion of solids contained amounts to 1,230 tons; which represents the portion restrained from the river. In the accomplishment of this work there has been used 757.78 tons of lime and 64.645 tons of alumina. During the year a constant study, with numerous experiments, has accomplished very satisfactory gains in the method of treatment. Under the former process, much of the value of the lime used was lost, owing to the rapidity with which it reached the sewage after being admitted to the agitators. By creating a more thorough solution before this point was reached, and adding the lime to the sewage in the form of milk of lime, has enabled a saving of 23 per cent. in this chemical alone, and a decrease of the power formerly required, of nearly 30 horse power. To dispose of the large and constant accumulations of sludge, has been a question that intruded itself into the foremost consideration. In the early spring there were eleven beds, covering an area of three acres, which had been used to excess and become nearly inoperative. Experiments had shown that if sufficient area was allowed, so that the depth of sludge did not exceed a few inches, its contraction would admit of rapid drying to a state of removal. With this object in view, an additional area of 5.7 acres has been added. While this work was in progress, the accidental discovery was made that in its dry state the sludge would readily burn. It was due to this circumstance that a small furnace about six feet square was built, similar to a self-feeding stove: the burning sludge beneath supplying the heat to dry the wet material above. It was found that sludge containing about 50 per cent. of water burned quite rapidly; while some containing as high as 72 per cent. was burned at the rate of 2.225 tons in nine hours, and this by its own combustion. The experiments in this direction have not been carried as far as desirable, but it is believed, from what has been learned, that it promises a solution of this most difficult problem in our sewage disposal. As above stated, the capacity of the plant is exceeded, in the quantity of sewage now treated. The velocity created by this excessive amount, does not allow sufficient time in which to precipitate; with a consequent loss of the full benefit of treatment. The completion of the separating system will largely increase the volume of precipitation from the concentrated sewage. Additional subsiding tanks will then be necessary, which, if anticipated, will in the interim permit of further advantage to the river from the same treatment as now pursued. This matter I respectfully refer to your consideration.

In conclusion, I wish to express my appreciation of the kindly assistance rendered by the Committee, of the intelligent supervision of Mr. H. P. Eddy at the purification works, to Mr. John Howell, the engineer in charge of construction, for the conscientious work performed, and to the men of the department.

Respectfully submitted,
FREDERICK A. McCLURE,
Superintendent of Sewers.

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ANNUAL REPORTS

OF THE 4

COMMITTEE ON SEWERS,

AND THE

SUPERINTENDENT OF SEWERS,

OF THE

CITY OF WORCESTER,

FOR THE YEAR ENDING NOVEMBER 30, 1892.

WORCESTER
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ANNUAL REPORTS

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1893.

REPORT

OF THE

JOINT STANDING COMMITTEE ON SEWERS.

To the Honorable City Council of the City of Worcester :—

In obedience to Section 7, Chapter 40, of the Laws and Ordinances of said City, the Joint Standing Committee on Sewers present their annual report, together with the report of the Superintendent of Sewers.

The work of the Sewer Department during the financial year of 1892, has consisted for the most part in the extension of what is termed "lateral sewers." The trunk or main carriers having been previously extended into the outlying districts, has permitted the construction of the smaller branches, thereby affording the much needed relief in the various portions of our city hitherto inaccessible. The amount of the extension is somewhat in advance of the past two or three seasons, amounting in total length constructed to 4.50 miles. The cost, however, has been brought within an exceedingly low figure for the different sizes.

The most difficult work for the season was the reconstruction of a portion of the 60-inch trunk sewer extending through Shrewsbury street, a detailed account of which will be found in the Superintendent's report.

By an arrangement with Mr. Stephen Salisbury, the City came into the possession of the dam and privilege in the Millbrook Sewer, known as the Court Mills privilege. This has always been a source of expense, and at times of freshet, one of solicitude, and it is of value to the department that it may now be abolished.

The Maintenance Department has also performed its duties in a very satisfactory and economical manner, especially when it is remembered that there are now 85.44 miles of sewers and 1,725 catch-basins to be constantly attended to.

The general condition of the entire system is excellent and satisfactorily performs its sanitary purposes.

The total expense for the past year has been as follows:—

For Construction	$51,074 68
" Purification works	27,575 24
" Maintenance	14,755 57

The purification plant at Quinsigamond has received much attention and great advance has been made towards a solution of the problem, while the original plant was able to deal with only a portion of the sewage the results attained seemed to your Committee to justify their further extension with a view to treating a larger amount of sewage. At the beginning of the year we were confronted with the task of devising some way to separate the sewage from the Millbrook water, in order to reduce the amount of treatment. It appearing that the number of precipitating basins was insufficient to treat a larger amount of sewage it was deemed advisable to begin the work at this point, and accordingly ten additional basins have been constructed with a view of treating all of the dry weather flow. This it is hoped will be of immediate advantage and benefit to the river below us.

Your Committee is also pleased to state that with increased length of sewers constructed during the season, and the constantly enlarging amount of work necessary to the maintenance of the system, the department through the economical management of its Superintendent and help, and a skilful arrangement of the work, is able to present its accounts at the close of the year largely within the appropriations in each division; while so large a balance is shown we feel that all the necessary work has been done and that the department has given entire satisfaction.

Your Committee is pleased to add further that F. A. McClure, late Superintendent of Sewers, was on November 1st elected City Engineer and immediately entered upon and assumed the duties of the office. The Committee now desire to express their appreciation of his able services and in the faithful and efficient discharge of his duties. The work accomplished by him has been done in a thorough and economical manner and to the entire satisfaction of the Committee. He carries with him, in his new field of usefulness and responsibility, the confidence and respect of the Committee and of his former employés.

Mr. H. P. Eddy, chemist at the purification works, was, upon the retirement and promotion of Mr. McClure, elected Superintendent of Sewers to fill the vacancy thus caused, and at once entered upon the duties of that responsible position. He is a close and attentive student and not a novice in the treatment of sewage disposal, and the results already attained have become manifest and are destined to be of the greatest benefit to the City and the people south of us. We feel assured that Mr. Eddy will make an efficient and active Superintendent, and that the department will continue in its present high standard of efficiency.

FRANCIS A. HARRINGTON,
FRANCIS PLUNKETT,
A. FRANK GATES,
EBEN F. THOMPSON,
GEO. S. DIXON,
FRANK A. ATHERTON,
JOHN J. FLAHERTY,
Joint Standing Committee on Sewers.

REPORT

OF THE

SUPERINTENDENT OF SEWERS.

To the Joint Standing Committee on Sewers:—

GENTLEMEN:—The rapid growth of Worcester is plainly visible in her Sewer Department; its work should follow that of the Water Department as rapidly as possible, in order to dispose of waste and properly maintain the already excellent sanitary condition of the city; consequently, the work is increasing in quantity and is of growing importance; the rapidly extending system incurs an ever increasing expense for maintenance, both for cleansing and repairs.

During the past year no trunk sewers have been built, the entire attention of the Department having been given to the construction of lateral sewers in the districts which had been previously provided with the main lines; this work has not been expensive, although a slightly greater length has been constructed than in recent years.

The districts now demanding immediate attention are New Worcester and Quinsigamond. At New Worcester, the trunk sewer should be extended from its terminus in Cambridge street across the square to the corner of Mill and Leicester streets, thus furnishing an outlet for the sewage of the large district lying south and west of Webster square. The Quinsigamond district requires two sewers,—one for surface water which should empty directly into the Blackstone river, and the other a surface sewer which should take the connections along Millbury and Greenwood streets and Outfall avenue. The sewer for surface water would receive no sewage and would take simply storm and subsoil water, which, if allowed to run into the Outfall sewer, would tend to further complicate the problem of sewage purification. Of these districts I would respectfully request your consideration.

One of the most difficult features of the work of the department during the past season was the reconstruction of a portion of the Shrewsbury street sewer; this was built during the year of 1884. In crossing that part of the locality known as the Meadows, the foundation, being rather unstable, has been affected by the raising of the street at different periods; the result has been to depress the sewer below its original grade, and by the lateral action of the fill to deprive it of proper side support. This caused several breaks longitudinally and permitted its original circular form to assume an oval one, increasing the diameter at the springing line eighteen inches or more, with a corresponding depression at the crown. Its dangerous condition was detected some time ago, and it has been necessary to support its arch for a distance of several hundred feet with heavy timbers in close order. These timbers required frequent renewals, and, aside from this expense, a total collapse has long been feared. By order of the City Government, the work of reconstruction was begun in July. There being very little rain during the progress of the work, the amount of sewage to handle was at no time large, and was easily provided for by a six-inch steam pump. As the sewer was stripped of the overlying material and the arch removed, the invert was found in fairly good condition, and, with its concrete foundation, was not disturbed. The old invert was thoroughly cleansed and washed and the new work built within it; at the springing line, to prevent distortion, five-eighths inch iron rods were inserted every eight feet, passing through the walls, and headed with cross bars of flat iron some eighteen inches in length. The arch was then constructed, and the material constituting the old arch was utilized in building a spandrel which extended down to the projecting part of the old concrete.

During the past year 582 permits for making house connections have been issued. At the present time the system includes 85.44 miles of sewers, with 3,338 manholes and 1,725 catch-basins; thus during the past year the system has increased to the extent of 4.50 miles of sewers, 220 manholes, and 58 catch-basins, as will be seen by the following table, showing the size, length, cost, and location of all the sewers built by the department during the year.

TABLE OF SEWERS CONSTRUCTED DURING FINANCIAL YEAR OF 1892.

STREET.	LOCATION.	SIZE. (Inches.)	LENGTH. (Feet.)	MAN-HOLES	COST.
Dryden,	Edgeworth st. to Hemans st.	12″	502.7	4	$586 26
Edgeworth,	Dryden st. to Sigourney st.	12″	675 3	6	724 25
North Byron,	Prescott st. to Nashua st.	12″	896.6	5	438 82
Cushing,	Crescent st. to Lincoln st.	20″ x 30″	372.7	3	3,590 26
"	" " "	18″	681.7	6	
Green lane,	Lincoln st. to Windsor st.	15″	637.0		
		12″	240.2	7	
Perkins,	Crescent st. to Paine st.	18″	186.0	2	410 61
"	" " "	15″	239.2	2	1,549 94
Paine,	Perkins st. to Cushing st.	15″ oval	527.0		
		12″	204.2	7	
Paine,	Harlow st. to Melville st.	15″	889.5	11	2,206 72
		12″	547.6		
Melville,	Paine st. easterly,	12″	124.0	2	
Lincoln,	Norton st. to Shattuck st.	24″ x 36″	80.2	1	1,214 57
Shattuck,	Lincoln st. easterly,	12″	684.0	5	
Lincoln,	Perkins st. to Cushing st.	18″	264.6	5	1,734 85
		15″ oval	275.2		
		12″	281.5	3	
Heardsleigh,	Summer st. to Fountain st.	12″	354.2	4	404 16
Catharine,	Hermitage brook to Rodney st.	15″	132.5	6	1,364 77
		12″	514.8		
Eastern ave.	Catharine st. to E. Kendall st.	12″	341.2	4	1,112 29
Kendall,	Hermitage br'k to Channing st.	12″	200.9	2	794 45
Channing,	Kendall st. to Catharine st.	12″	580.5	5	
Hooper,	Catharine st. to Kendall st.	12″	421.5	4	757 98
Merrifield,	Belmont st. southerly,	15″	298.8	2	404 60
Gage,	E. Shelby st. to Elliott st.	12″	203.4	4	567 07
		10″	300.0		
Berkeley,	Gage st. to Eastern ave.	12″	181.3	3	371 80
Adams,	Shrewsbury st. northerly,	20″ x 30″	269.1	3	601 07
Wilson,	Marshall st. east'ly and west'ly,	12″	727.9	7	985 30
Marshall,	Wilson st. to Fobes st.	15″	233.1	2	327 16
Henry,	E. Worcester to Shrewsbury st.	12″	358.2	4	347 87
Wall,	Branch st. southerly,	12″	87.5	1	136 16
Grafton st. ct.	Grafton st. southerly,	12″	320.7	3	457 51
Ledge,	Extended to Providence st.	15″	66.6	5	555 59
		12″	238.9		
Woodside,	Perry ave. to Vernon st.	12″	778.0	6	1,706 33
Perry ave.	Seymore st. to Stone st.	15″	542.4	5	818 06
		12″	166.0		
Whipple,	Millbury st. to Steele st.	10″	306.0	14	1,527 83
		8″	1,521.3		
Carlstad,	Whipple st. southerly,	8″	517.3	5	452 83
Ekmans,	Greenwood st. westerly,	8″	163.7	2	350 00
Sherman,	Kansas st. to Pitt st.	10″	218.7	3	208 30
Camp,	Cambridge st. southerly,	15″ oval	447.6	7	1,699 25
		12″	412.4		
Camp st. ct.	Camp st. easterly,	10″	199.1	2	
Armory,	Grand st. easterly,	18″	371.9	5	895 37
		15″ oval	166.3		
		12″	116.6		
Grand,	Carson st. to Grand st. ct.	15″ oval	196.7	2	818 38
Grand st. ct.	Grand st. westerly,	12″	317.7	3	
Tainter st. ct.	Tainter st. westerly,	10″	118.3	2	205 53
Jaques and Webster,	River to Boston & Albany bridge for Highway Dept.	15″	944.0	7	1,458 00
Woodbine,	Maywood st. to Oliver st.	12″	487.0	4	572 37
Main,	Hawthorn st. westerly,	12″	97.5	1	159 14
Mason,	Extended to Tufts st.	12″	371.1	3	300 74
"	Parker st. southerly,	15″	305.1	3	579 90
		12″	108.8		
Winfield, Tufts, and Abbott,	Parker st. to Chandler st.	18″	177.3	9	809 68
		12″	376.5		
		9″	524.0		
Chandler,	Park ave. to Abbott st.	15″ oval	552.0	2	1,214 71
Abbott,	Chandler st. to Pleasant st.	12″	472.9	6	
Queen,	King st. easterly,	12″	121.5	1	198 09
Shrewsbury,	Reconstructed,	60″ round	617.0	4	6,192 94

The work of maintaining the sewer system has not been excessive during the season because of the absence of heavy rains which wash the road detritus into the catch-basins. This is an item of great importance, as the material which finds its way into the basins has to be removed in a very wet state in pails; it then has to be carted to the dumping grounds in small loads because of its fluidity and weight. During the past season 4,918 loads have been removed in the above manner. This obviously incurs a great expense which would be considerably decreased if the material were disposed of before finding its way into the basins.

An unusually large number of repairs have been made during the year, which, of course, is a matter to be anticipated as the system increases in extent. This season 130 basins and 239 manholes have been repaired in some way.

Very valuable additions to the working outfit of the department have been made in the form of machinery; circular and band saws have been placed in the carpenter shop, as has also a wood-turning lathe. Perhaps the most important acquisition is that of a Carson excavator, the woodwork of which was made by the department, the iron fittings and the buckets alone being purchased of the Carson Company. The value of this machine to the department can hardly be overstated, it having largely paid for itself in the reconstruction of the Shrewsbury street sewer, which, only with great difficulty, could have been accomplished without the machine.

In the early part of May, in accordance with an order passed by the City Government, work was begun on the new settling basins at the Purification Plant in Quinsigamond. The construction of this addition to the original plant has rapidly progressed during the summer and fall. The masonry is practically complete; the gates and emptying arrangements, and considerable machinery yet remain to be added. This, it is hoped, will be accomplished during the winter and spring, so that the entire plant may be ready for operation in the early summer.

The work done at the Purification Plant during the year has been very largely experimental. The regular treatment of sewage has been interrupted by the experiments carried out at the works, by the construction of the additional basins, and also by being very frequently obliged to shut down for five or six hours while connections were being made with the outfall sewer. This interruption, by making house connections, will be a great annoyance when all the sewage is being treated, and should be remedied by the construction of a surface sewer, which should enter the outfall near its mouth; such a plan would, if carried out, greatly reduce the cost of house connections along the line, as the main sewer is 18 feet to 25 feet deep.

During the winter a large number of analyses of lime were made, resulting in the selection of a grade better adapted to sewage treatment, and which, taking into account the quality, has proved to be about twenty per cent. cheaper than that formerly used.

One of the most difficult problems connected with the purification of sewage by chemical precipitation, not only in this city but in nearly every instance in which the method has been tried on a large scale, has been the ultimate disposal of the sludge. To this branch of the work considerable attention has been paid. From the first, efforts have been made to have the farmers try the sludge as a fertilizer, but the prejudice against it was so great that until last spring no one could be found who would try it. At that time several enterprising farmers made a trial of the material; no little surprise was experienced when it was found that the experiments were successful. Crops of Hungarian grass, corn, oats, potatoes, and tomatoes grew luxuriantly; a gravelly knoll on which sludge had been spread produced nearly three tons Hungarian per acre. The crops raised on sludge were so successful that no trouble has been experienced in disposing of the accumulation thus far. Thus one of the most vexing problems connected with the disposal of the sewage has been economically settled, for the present at least.

Respectfully submitted.

HARRISON P. EDDY,
Superintendent of Sewers.

WORCESTER, November 30, 1892.

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ANNUAL REPORT

OF THE

Superintendent of Sewer

OF THE

CITY OF WORCESTER

FOR THE

YEAR ENDING NOVEMBER 30 [illegible]

WORCESTER, MASS.
PRESS OF F. S. BLANCHARD & CO.,
54 FRONT STREET
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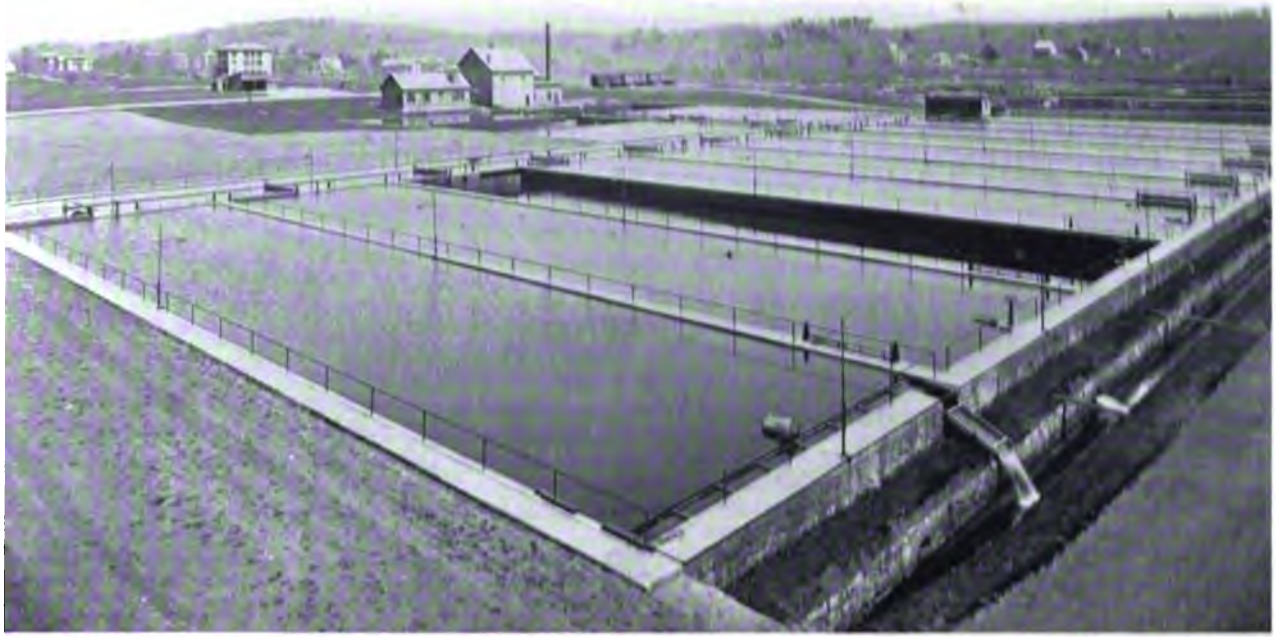

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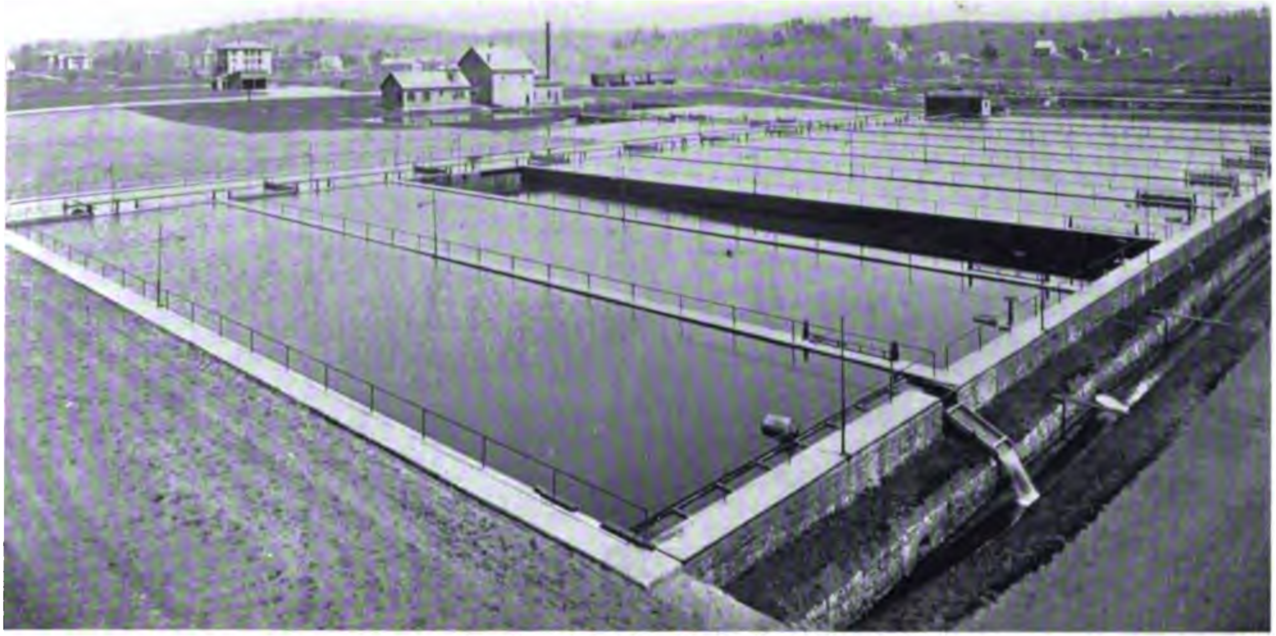
1896.



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To the Honorable City Council of the City of Worcester:—

In compliance with Section 21, Chapter 34 of the City Ordinances, the following report of the work and condition of the Sewer Department for the fiscal year of 1895 is prepared.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

OFFICE OF THE SEWER DEPARTMENT,
December 1, 1895.

MEMBERS OF COMMITTEE ON SEWERS, 1895.

President of the Board of Aldermen:

RUFUS B. DODGE, JR., *Chairman.*

Alderman **DANIEL A. HARRINGTON,**

Councilman **GEORGE S. HATCH,**

Councilman **JOHN J. FLAHERTY,**

Councilman **DAVID BOYDEN.**

REPORT OF THE SUPERINTENDENT OF SEWERS.

CONSTRUCTION.

This branch of the work of the department has been unusually quiet during the past year, and the sewers which have been constructed have been small, and in most cases have presented no very complicated or difficult problems. As for several years past, the work has not been confined to the centre and more thickly populated portions of the city, but has reached out into the surrounding territory, where real estate is being developed, and where the sewers are needed to accommodate newly built houses. With extensions in this direction the divisions of the system become more marked, the small sewers for house sewage alone becoming more numerous, and the demand for sewers for the removal of storm water becoming imperative.

As between the accommodation of a community with house sewers and surface sewers, the former is by all means the more important, and should, in the great majority of cases, take precedence over the latter, yet it would seem to be unwise to neglect the disposal of surface water. In a city abounding in hills—and Worcester is surely well supplied with this kind of territory—the streets cannot be properly maintained without great expense unless the water resulting from storms, melting snow, and more particularly from showers, is removed from the gutters at frequent intervals. To effect this the department has always placed catch-basins wherever deemed expedient, and a special effort should be made in this direction next year.

The total resources of the department during the year have amounted to $130,298.56, a detailed account of which may be found in the table below. The transfer of the revenue derived from sewer assessments and liquor licenses so late in the season accounts in part for the balances in the construction and purification accounts:

SUMMARY OF FINANCIAL RESOURCES FOR 1895.

	MAINTENANCE.	CONSTRUCTION.	PURIFICATION.
Balance Dec. 1, 1894,	$584 87	$11,846 91	$1,184 72
Appropriation,	17,000 00	30,000 00	32,000 00
Liquor Money,	——	5,000 00	8,000 00
Assessments,	——	2,927 97	17,927 98
Revenue,	1,185 67	2,478 26	162 18
Total,	18,770 54	52,253 14	59,274 88
Total expended,	18,703 84	50,265 77	46,847 46
Balance December 1, 1895,	66 70	1,987 37	12,427 42

The extension of the surface sewer in Main street from Webster square to Marble street has enabled the department to construct eight catch-basins, which will be sufficient to properly care for all the water reaching this portion of Main street, and will undoubtedly prevent the recurrence of those floods at the square which have for so many years been a source of great annoyance.

Surface sewers are greatly needed at the present time in Pleasant street west of Newton square, in Vernon and adjacent streets, and at Quinsigamond Village south of the watering trough. Work upon the former has been begun, but a further extension is much needed.

The separate system has been pushed out Webster street as far as Hope cemetery, thus affording relief to a comparatively large population living in that vicinity. As the sewer at Webster square was too high to be extended under the river at the proper grade, a twenty-four-inch round inverted syphon was constructed, similar in every respect to those built last year in Southbridge street and Leicester street, now Main street.

Work was begun in the early part of the summer upon the sewer for the relief of the Bloomingdale district, and is still in progress, although the portion already ordered is nearly completed. This sewer connects with the sewer in Putnam lane, and runs through private land owned by Messrs. G. F. Swift & Co., James Draper and Jerome C. Field. It follows the foot of the hill until it reaches a point about in the middle of the property owned by Mr. Field, where it turns up toward Plantation street. In this way no great depth of ledge will be encountered, and the construction will cost much less than if the location was confined to streets now existing. The soil of this section of the city consists almost entirely of clay or hard-pan resting upon ledge. The natural drainage is very poor, and a system of sewers will be greatly appreciated by the residents.

A sewer has been constructed through land formerly known as Nashua street, but now owned by the Boston & Maine Railroad Company and the Worcester, Nashua & Rochester Railroad Company, under the tracks of these companies, thus affording an outlet into the Crescent street sewer for Messenger hill. This sewer was also much needed, as the soil is mostly of a hard and compact nature, the drainage being very poor.

A special effort has been made by this department during the year to leave the streets in which sewers have been constructed in as good condition as possible. Care has been taken to leave as little superfluous material over ditches as would ensure no lack of filling for future settlement. It is intended to go over every street in which a sewer has been constructed during the season, as often as once every month, raking off loose stones and leveling and filling as required. Near the close of the year this circuit was made and the work done with greater care than previously. This will be repeated when the frost is out of the ground in the spring. In this way it is hoped to keep the streets in as good condition as possible, and it is the intention of the department to maintain this rigid inspection, believing that it is unjust to the Highway Department to leave the streets in any other condition than the best which it is practicable to obtain. It is a fact that material filled into a ditch in the ordinary way will settle somewhat, and consequently an excess of filling is piled upon the street over the sewer. This excess is reduced as low as possible, depending upon the kind of material, and if found to be too high, after allowing a suitable length of time for settlement, is removed. Experiments are under way in the laboratory to determine the amount of settlement of different materials. This test will be supplemented by tests upon the streets next year, and it is hoped to gain information which may prove of value in the future.

A table of the stock used, together with the prices paid for the same, is herewith presented, as is also a brief schedule of the property owned by the department, and a table of the sewers constructed in the fiscal year of 1895, with statistics, which may be of interest. The table of stock includes that used in the purification and maintenance departments as well as in construction :

MATERIALS USED BY THE SEWER DEPARTMENT IN 1895.

MATERIAL.	CONTRACTOR.	PRICE PAID.		APPROXIMATE AMOUNTS USED.	
		1894.	1895.	1894.	1895.
Sand,	Amos M. Eaton,	$1.25	$1.25	925 Cu. Yards	454.5 Cu. yards
Cement,	Frank E. Powers,	.98	1.04	3,267 barrels	1,994 barrels
Pipe,	James Draper,	—	—	20,000 feet	18,439.7 feet
Brick,	Damon Brick Co.,	6.50	6.35	750,000	493,000
Lime,	Frank E. Powers,	6.50	5.75	2,100 tons	3,243 tons

SCHEDULE OF PROPERTY.

Personal property,	$17,477 34	
Hammond street, 1700 feet of land,	425 00	
Disposal works, land,	9,300 00	
Buildings and machinery, East Worcester street,	2,790 00	
Buildings and machinery, disposal works,	8,425 00	
		$38,417 34

TABLE OF SEWERS CONSTRUCTED DURING THE FINANCIAL YEAR OF 1895.

STREET.	LOCATION.	SIZE Inches	Length Feet	M. H.	COST.
Prescott,	Terminus northerly.	12	[illegible]	3	$1100 [illegible]
Paine,	Perkins southerly.	12	[illegible]	2	[illegible]
Norton	Paine to Lincoln.	8	[illegible]	2	[illegible]
Burncoat,	Melrose northerly.	30 x 20 15 round	[illegible]	4	[illegible]
Nashua, Byron,	Crescent westerly.	20	[illegible]		
Edgeworth and	Byron to Whittier.	15	[illegible]	11	[illegible]
Whittier.	Edgeworth to Hemans.	12	[illegible]		
Hemans,	Whittier to Insley.	10	[illegible]	6	[illegible]
West,	Terminus northerly.	12	[illegible]	2	[illegible]
Fruit,	Dayton southerly.	8	[illegible]	2	[illegible]
North Merrick,	Elm northerly.	8	[illegible]	2	[illegible]
No. Merrick Pl.,	North Merrick westerly.	8	[illegible]	2	[illegible]
Genesee,	Highland to Mt. Hope.	24 round 15	[illegible]	5	[illegible]
Highland,	Pleasant easterly.	[illegible]	[illegible]	5	[illegible]
Queen,	Terminus southerly.	12	[illegible]	3	[illegible]
Bancroft,	Bluff southerly.	12	[illegible]	2	[illegible]
Barbour,	Dewey to Mason.	8	[illegible]	2	[illegible]
Oread place,	Valley to Alden.	12	[illegible]	3	[illegible]
Clement,	Main northerly.	8	[illegible]	3	[illegible]
Marble,	Main northerly.	8	[illegible]	1	[illegible]
Main (surface),	Webster Sq. to Marble.	15 12	[illegible]	22	[illegible]
Park Ave. Pl.,	Park Ave. southerly.	8	[illegible]	2	[illegible]
Mill (surface),	Main northerly.	21 15	[illegible]	1	[illegible]
Lake,	Main to Baker.	10	[illegible]	1	[illegible]
Wayne,	Main to Baker.	8	[illegible]	1	[illegible]
Montague,	Main to Baker.	8	[illegible]	1	[illegible]
Webster,		20 round	[illegible]		
Webster Ct.,	Terminus southerly.	28 x 31	[illegible]		
Jacques		24 x 27	[illegible]		
Webster,		24 x 26	[illegible]	30	[illegible]
21 Order.		24	[illegible]		
		22	[illegible]		
Sutton lane,	Fremont southerly.	8	[illegible]	2	[illegible]
Illinois,	Terminus westerly.	21	[illegible]	2	[illegible]
Beckman,	Whipple northerly.	8	[illegible]	2	[illegible]
Ekman,	Terminus westerly.	8	[illegible]	2	[illegible]
Esther,	Vernon westerly.	8	[illegible]	4	[illegible]
Pattison,	Terminus easterly.	12	[illegible]	2	[illegible]
Waverley,	Providence easterly.	15	[illegible]	2	[illegible]
Union Ave.,	Cutler easterly.	30 x 24	[illegible]		
Houghton (N.),	Union Ave. northerly.	12	[illegible]		
Houghton (S),	Union Ave. southerly.	15	[illegible]	14	2400 [illegible]
Union Ave.,	Houghton to Arthur.	8	[illegible]		
Caroline,	Grafton to Plantation.	12	[illegible]	4	[illegible]
Bloomingdale,	Terminus easterly.	24 x 36	[illegible]	12	[illegible]
Windsor,	Terminus northerly.	12	[illegible]	1	[illegible]
Windsor,	Terminus to Orne,	12	[illegible]	2	[illegible]
Windsor,	Green lane southerly.	12	[illegible]	2	[illegible]

The total length of sewers constructed during the year is but 3.87 miles, of which .92 of a mile is trunk sewer. The proportion of sewers built in the separate system to the total length constructed is 35.18%, or slightly over one-third. The sewers built required the construction of 168 man-holes and 65 catch-basins. The system now contains 99.29 miles of sewers, 3,725 man-holes, 1,855 catch-basins. The total number of permits issued to contractors during the year to make house connections is 382, of which one has not been used and six were for repairs of drains already constructed.

The buildings and tools of the department are all in good condition. A ten-horse power electric motor, "Lundell," has been put into the shop, and is a very valuable acquisition. The water motor was scarcely able to do the work and was considerably more expensive at the price charged for city water. No other machinery has been added during the year, largely because of lack of room at the shop to accommodate it.

An upright drill is much needed and ought to be purchased very soon. The horses owned by the department are kept in a shed poorly adapted to the purpose, which is hired at a price which would pay interest on the cost of a well-equipped, commodious stable which would accommodate several more horses than now owned by the department.

MAINTENANCE.

The many heavy rains of the past season have necessitated the frequent cleaning of sewers and catch-basins, especially the latter. The sewer system now contains, as stated under another heading, 1,855 basins, and upon even a superficial consideration of the matter, it will be evident that with the streets as at present maintained, every rain of any considerable magnitude will fill many of these basins, and when the rains follow one another in rapid succession, it is very apparent that great expense is incurred by keeping this part of the system in good working condition.

Over 7,000 loads of detritus from the streets have been shoveled out of the basins through 24" by 28" holes (except in cases where the mud was so soft that it had to be removed in buckets), then shoveled into carts and hauled to the prescribed dumps. Many of the loads are very wet, and consequently if hauled in an ordinary tip-cart, the body of the cart can only be filled about three-quarters full. To reduce the expense of hauling as much as possible, a new patent steel cart was purchased in the spring.

This has proved a valuable investment, as with it nearly twice as much of the soft material can be hauled in one load as with the ordinary tip-cart. The department now owns two of these carts, and while they cost an exorbitant price, they do pay a handsome interest on the money invested.

During the year 7,542 loads of refuse have been removed from the basins. This is 1,223 loads in excess of the output for 1894. In spite of the difficulties attending this work, such as bailing water, handling twice, small loads and long hauls, the cost has amounted to but seventy cents per cubic yard. This includes removing snow from the inlets to basins, and freeing basins stopped by ice or other obstacles.

Flushing and scraping have been continued during the year, the latter having been necessitated largely by a considerable amount of street detritus which passed the basins during storms.

William Donnelly, a foreman who had charge of this branch of the work for a number of years, and who had been connected with work on the sewers of the city for more than twenty-five years, died during the latter part of the summer. Mr. Donnelly had been connected with this part of the city work for so many years that his presence will be much missed.

SEPARATION OF NORTH POND WATER FROM THE SEWAGE.

It is encouraging to note that this problem, which has confronted the department for so many years, and which has been touched upon in so many reports, has finally assumed definite form. A problem of such magnitude cannot be successfully solved without much study and a thorough canvass of the many difficulties and obstacles which might be overlooked in a superficial examination, but which readily appear upon a detailed investigation. It is hoped that construction may follow close upon the report of the city engineer, and that it will be prosecuted to an early completion.

PURIFICATION.

With the close of the year 1895, the sewage purificatien plant at Quinsigamond completes its fifth year of operation. The work begun in 1890 without previous experience, experimentation, or even an example of a well managed and efficient plant of this kind, either upon this side of the Atlantic or the other, has been continued up to the present time; and during this time the amount of sewage treated has increased from about three million gallons to something over fifteen and one-half million gallons daily. As cited in previous reports, the plant has been enlarged, both in respect to machinery and the number of settling basins, the latter having been increased to about three times their original capacity.

The first aim during this year, as in previous years, has been to maintain the highest efficiency possible. The second in importance has been to do the maximum amount of work with the least money.

To attain whatever success has been attained, a careful, constant study has been made, both in the laboratories and upon a larger scale with the plant itself, of the many and various problems as they have presented themselves.

TREATMENT OF SEWAGE.

The treatment of the sewage has been rendered more difficult than in former years by the increased volume received, and the copperas and vitriol contained in it. These chemicals, which are discharged promiscuously throughout the city by foundries, wire working establishments and other manufactories, require large amounts of lime to neutralize them, and they *must* be neutralized before sedimentation can be effected to a satisfactory degree. The velocity created by so large a flow of sewage through the settling basins hinders precipitation, and every effort must be made to counteract this effect so far as possible. To these causes is due the use of a considerable portion of the 3,000 tons of quicklime put into the sewage during the year.

The volume of sewage treated has averaged about 15.7 million gallons per day during the year. For the treatment of this amount of sewage, about 3,000 tons of lime have been used, amounting to 1,030 pounds per million gallons, or about 7.21 grains per U. S. gallon.

From the sewage there have been removed in form of wet sludge 66,440,333 gallons, equivalent to 1.16% of the flow. The sludge as pumped contained 7,972 tons of dry solids.

As a result of the treatment, about 51.45% of the organic matter contained in the sewage has been removed, and the water has been turned into the river practically as clear and sparkling as it was when rippling along the brooks of Leicester or Holden, before its entrance into the pipes which supply the city with pure water. In addition to this *appearance*, it is a fact that this effluent water has attained a degree of purity which ensures no further putrefaction; it will not become offensive to the sense of smell.

In this connection it may be of interest to compare the efficiency of the treatment from year to year as indicated by the daily analyses of sewage and effluent. From table VI we see that there has been a steady increase in the per cent. of organic matter, as indicated by the test for albuminoid ammonia, removed from the sewage. This increased efficiency is also apparent from the determination of oxygen consumed. It will also be noticed that in spite of the frequent rains and continued high water, the per cent. of suspended organic matter removed from the sewage is even greater than last year.

TABLE VI.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE.

DESCRIPTION.	1893.	1894.	1895.
Total amount (by evaporation),	50.88	49.35	——
Amount in suspension (by evaporation),	90.67	94.45	——
Total amount (by albuminoid ammonia),	48.49	50.79	51.63
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11
Total amount (by oxygen consumed),	33.65	43.84	54.35
Amount in suspension (by oxygen consumed),	80.85	81.08	78.01

Note: Although the determination of oxygen consumed has been made throughout the year, it is not considered as reliable as the determinations of albuminoid ammonia, because of large amounts of iron present in the sewage, and also because the determination itself is by no means as satisfactory as that for albuminoid ammonia.

From Table VII it will be observed that in the winter and spring, seven months, there was an improvement over the corresponding seasons of the year previous, but that in the summer and autumn there was a slight decline. This decline was due to the large flow of sewage, or, more properly, the large dilution, and it was only with the greatest care that the drop was confined to so small a per cent. If the figures of Table VIII are examined and compared, it will be seen that the decline is confined to the months of October and November, while those previous are substantially as high as 1894. It will be remembered that a very heavy rainfall occurred on October 12, 13 and 14, when the gauge at the precipitation works recorded 7.72 inches. The total rainfall for October was 9.57 inches, and for November 6.39 inches, both of which are extremely high. This is simply another illustration of the necessity of a separation of as much as possible of the water finding its way into the sewers, yet not sewage proper.

TABLE VII.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE BY SEASONS.

DESCRIPTION.	DEC. TO JUL.		JULY TO DEC.		
	1894.	1895.	1893.	1894.	1895.
Total amount (by evaporation),	42.76	—	50.88	55.02	—
Amount in suspension (by evaporation),	93.08	—	90.67	95.76	—
Total amount (by albuminoid ammonia),	46.63	49.69	48.49	53.78	52.93
Amount in suspension (by albuminoid ammonia)	83.26	91.73	76.67	94.36	90.75
Total amount (by oxygen consumed),	37.11	46.92	33.65	50.23	61.08
Amount in suspension (by oxygen consumed),	89.27	82.95	80.85	92.42	72.91

The monthly averages of the composition of the sewage and effluent, together with the per cent. of the organic matter removed, can be studied in detail from Table VIII. The diagram lettered A will be of assistance in such an examination. It is interesting as well as important to notice that the work done compares directly with the flow of sewage; that is, with a given plant and sewage and a nearly uniform treatment, the per cent. of organic matter removed by chemical precipitation will vary, approximately, with the volume.

Another way of stating the proposition would be as follows: Where a sewage receives dilution, but is itself constant in volume and composition, the per cent. of organic matter removed by chemical precipitation will be approximately proportional to the amount of diluting water, true within reasonable limits.

TABLE VIII.

MONTHLY AVERAGES OF ANALYSES OF SEWAGE AND EFFLUENT.

(*Parts per 100,000.*)

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.
	Free.	ALBUMINOID.					
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	
Sewage, December, 1894	1.400	.550	.278	.272	5.38	3 16	6.30
Effluent, " "	1 292	.273	.240	.033	3.02	2.83	6.29
Parts removed	.108	.277	.038	239	2.36	0.33	0.01
Per cent. removed	7.71	50.36	13 68	87.94	43.86	10.44	0.16
Sewage, January, 1895	1.186	.471	.254	217	5.23	3.21	6.38
Effluent, " "	1.001	.250	.229	.021	2.85	2.65	6.28
Parts removed	.186	.221	025	.196	2.38	0.56	0.10
Per cent. removed	15.69	46.92	9 84	90 33	45.51	17.45	1.57
Sewage, February, 1895	1 378	.615	310	305	5.60	3.46	7.27
Effluent, " "	1.158	.296	.274	.022	3.11	2.91	7.27
Parts removed	.220	.319	.036	.283	2.49	0.55	0.00
Per cent. removed	15.96	51.87	11 61	92.79	44.46	15.90	0.00
Sewage, March, 1895	.731	.353	.178	.175	3.76	2.20	4.35
Effluent, " "	.644	.182	.169	.013	1.89	1.77	4.37
Parts removed	087	.171	009	162	1.87	0.43	-.02
Per cent. removed	11 91	48.44	5.06	92.58	49.73	19.54	-0.46
Sewage, April, 1895	.730	.332	173	.159	3.70	2.23	4.32
Effluent, " "	.630	.185	.172	.013	1.98	1.81	4.30
Parts removed	.100	.147	001	.146	1.72	0.42	0.02
Per cent. removed	13.70	44 28	.58	89.74	46.48	18.83	0.46
Sewage, May, 1895	1 218	603	.256	.347	5.59	3.16	6 36
Effluent, " "	1.071	.285	.265	.020	2.68	2.48	6.34
Parts removed	.147	318	-.009	.327	2.91	0.68	0 02
Per cent. removed	12 07	52.73	-3.52	94.23	50.27	21.52	0.31
Sewage, June, 1895	1.346	.607	.262	.345	6.04	2.70	6.61
Effluent, " "	1.223	.291	.261	.030	2.42	2.20	6.66
Parts removed	.123	.316	.001	.315	3.62	0.50	-.05
Per cent. removed	9.14	52 06	0.38	91.31	59.94	18.52	-0.76
Sewage, July, 1895	1.432	.604	.285	.319	7.10	3.25	6.90
Effluent, " "	1.210	.272	.239	.033	2.57	2.44	6.73
Parts removed	.222	332	.046	.286	4.53	0 81	0.17
Per cent. removed	15 51	54 96	16 14	89.66	63.80	24.92	2.46
Sewage, August, 1895	1.240	575	.267	.308	5.96	3.28	6 50
Effluent, " "	1.069	.272	.245	.027	2.18	2.18	6.26
Parts removed	.171	303	.022	.281	3.78	1.10	0.24
Per cent. removed	10.56	52 69	8.24	91.22	63.43	33.54	3.69
Sewage, September, 1895	1.500	.718	.333	.385	6.23	3.28	7.09
Effluent, " "	1.270	300	.280	.020	2.25	2.25	6 77
Parts removed	.230	.418	.053	.365	3.98	1.03	0.32
Per cent. removed	15.33	58 22	15.92	94.79	63.72	31.39	4.51
Sewage, October, 1895	1.165	487	.222	.265	5.00	2.88	5.80
Effluent, " "	.968	.246	.209	.037	2.13	2.02	5.82
Parts removed	.197	.241	.013	.228	2.87	0.86	-.02
Per cent. removed	16.90	49.49	5.86	86.04	57.40	29.86	-0.34
Sewage, November, 1895	.590	.306	.166	.140	3.59	2.11	3.87
Effluent, " "	.564	.171	.154	.017	1.75	1.67	3.90
Parts removed	.026	.135	.012	.123	1.84	0.44	-.03
Per cent. removed	4.41	44 12	7.23	87.86	51.25	20.85	-0.77
Sewage for year ending December 1, 1895	1 160	.518	.249	.270	5.27	2.91	5 98
Effluent " " " " "	1.008	.252	.228	.024	2.40	2.27	5.92
Parts removed	.151	.2665	.021	.246	2.86	0.64	0.063
Per cent. removed	13 02	51.63	8.43	91.11	54.35	21.99	1.05

Note: Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of sampling. Effluent samples consist of twenty-four portions taken hourly.

Note: Determinations have been omitted this year on account of the large amount of copperas and su'p'.uric acid in the sewage.

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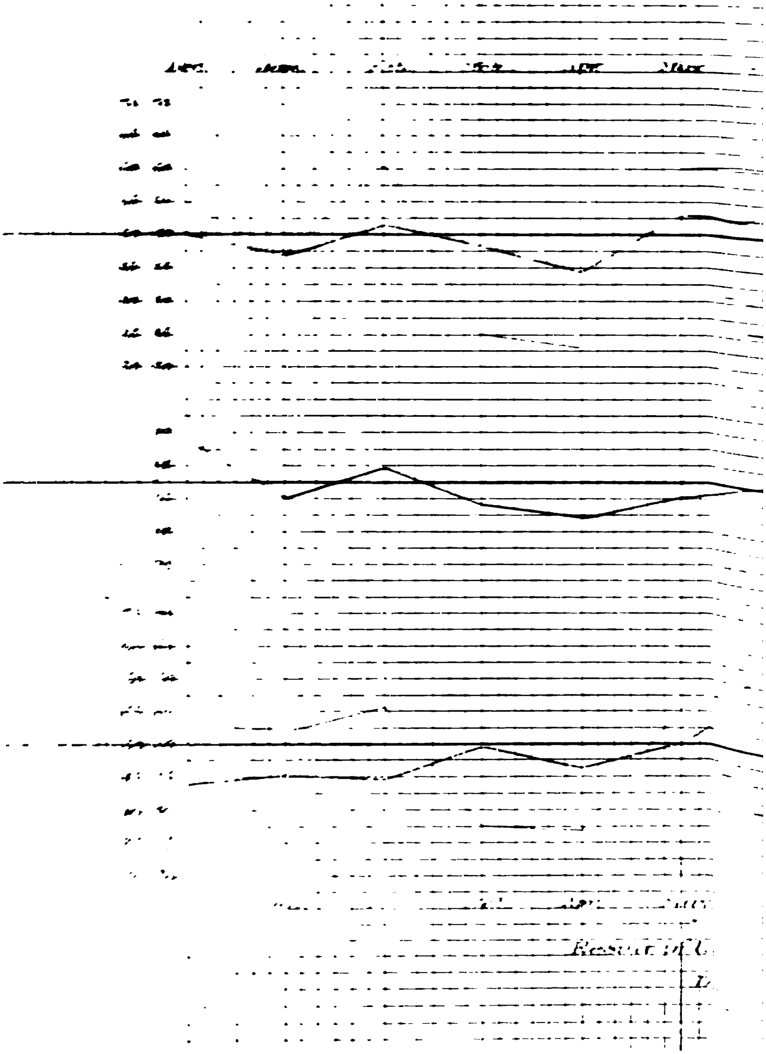

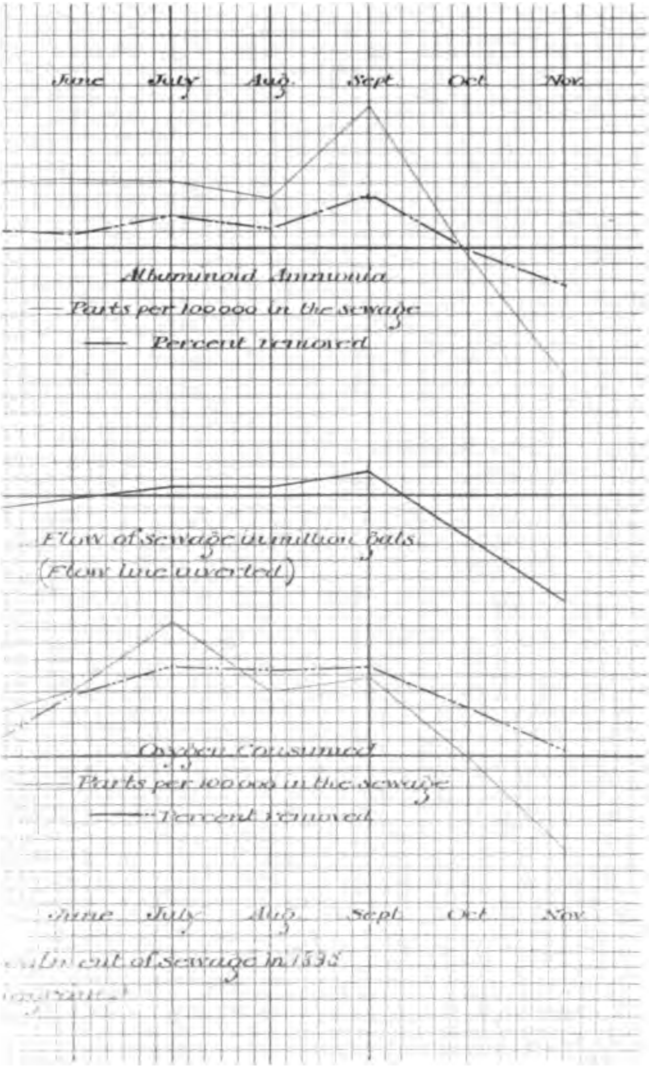
June
July
Aug.
Sept.
Oct.
Nov.
Albuminoid Ammonia
Parts per 100 000 in the sewage
Percent removed
Flow of sewage in million gals.
(Flow line inverted)
Oxygen Consumed
Parts per 100 000 in the sewage
Percent removed
June
July
Aug
Sept
Oct
Nov
ent of sewage in 1898

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CONDITION OF BLACKSTONE RIVER.

The regular weekly examinations of the Blackstone river have been continued as in previous years. It is encouraging to note that the condition of the river, chemically considered, is better than in previous years, as seen from Tables XI and XII, and also from Table XIII, compiled from the records of the State Board of Health. This latter table shows an improvement of more than 35 per cent. over 1894, and shows that there is less decomposable organic matter in the river, according to the most reliable test—albuminoid ammonia—than there has been in any year since the board began its periodic investigations, viz., 1887.

The precipitation plant was started in 1890, and the river has been during the past year, according to the figures of the same board, 39.81 per cent. better than in that year. But, as that plant was in operation but one-half of 1890, it would be nearer correct to compare 1891 with 1895. This comparison shows that an improvement of 40.45 per cent. has been made. These records may be found in the State Board of Health report for 1894, second table on page 375. The figures for 1895 can be obtained from the board upon request. This table includes the six months from June to November inclusive, and is one of the most important, as it is during this period that the river would be liable to evolve offensive odors. Similar facts may, however, be observed from the table directly opposite, on page 374, which includes the entire year.

The facts learned from these records would seem to be of more value, because not seriously affected by the high water of October and November, for the improvement noted for the months June to October is over 32 per cent. These figures are especially interesting when considered as coming from a disinterested party, or at least a party not the least interested in behalf of Worcester.

Before closing it is the desire of the superintendent to express to the committee his appreciation for the many courtesies received at its hands, and for the lively interest in the work in which the department has been engaged, which has been manifested by its individual members throughout the year. It is also a pleasure to allude to the faithful manner in which Mr. Matthew Gault, the engineer, and Mr. Julius W. Bugbee, the chemist, connected with the department have performed their duties.

TABLE XI.

AVERAGES OF WEEKLY ANALYSES OF WATER TAKEN FROM THE BLACKSTONE RIVER FROM DECEMBER, 1894, TO JULY, 1895; JULY, 1895, TO DECEMBER, 1895, AND FROM DECEMBER, 1894, TO DECEMBER, 1895.

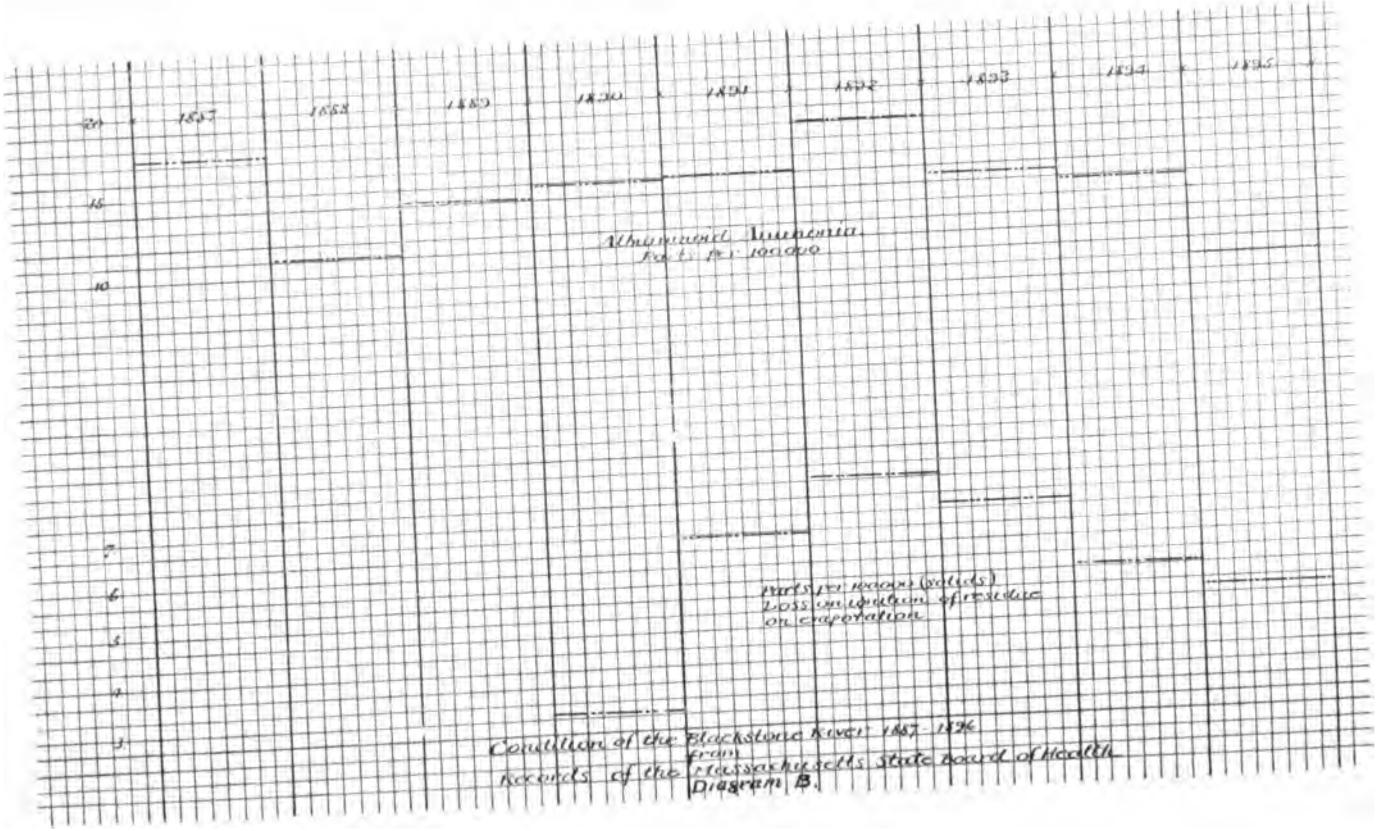
(Parts per 100,000.)

WHERE TAKEN.	DATE OF COLLECTION.	AMMONIA.				NITROGEN AS—		OXYGEN CONSUMED.		Chlorine.	Remarks.
		Free.	Albuminoid.								
			Total.	Dissolved.	Suspended.	Nitrates.	Nitrites.	Unfiltered.	Filtered.		
Washburn & Moen pond	Dec. 1, 1894, to July 1, 1895	.019	.082	—	—	.0035	.0006	.73	—	.63	Above works.
" " "	July 1, 1895, to Dec. 1, 1895	.027	.050	—	—	.1340	.0012	1.14	—	.75	" "
" " "	Dec. 1, 1894, to Dec. 1, 1895	.022	.039	—	—	.0570	.0008	.90	—	.68	" "
Bridge	Dec. 1, 1894, to July 1, 1895	.055	.050	—	—	.0026	.0000	.96	—	.98	" "
"	July 1, 1895, to Dec. 1, 1895	.180	.056	—	—	.1040	.0081	1.05	1.03	1.10	" "
"	Dec. 1, 1894, to Dec. 1, 1895	.077	.052	—	—	.0440	.0013	1.00	.99	1.08	" "
Swamp	Dec. 1, 1894, to July 1, 1895	.284	.109	.106	.003	.0160	.0005	1.30	1.28	2.34	Below "
"	July 1, 1895, to Dec. 1, 1895	.358	.139	—	—	.1180	.0079	1.24	1.22	2.47	" "
"	Dec. 1, 1894, to Dec. 1, 1895	.315	.122	.120	.002	.0590	.0036	1.27	1.25	2.39	" "
Morse pond	Dec. 1, 1894, to July 1, 1895	.359	.093	.091	.002	.0120	.0006	1.15	1.14	2.68	" "
" "	July 1, 1895, to Dec. 1, 1895	.543	.157	—	—	.1590	.0045	1.24	—	3.05	" "
" "	Dec. 1, 1894, to Dec. 1, 1895	.456	.120	.119	.001	.0740	.0023	1.19	1.19	2.83	" "
Aldrich pond	Dec. 1, 1894, to July 1, 1895	.309	.082	.082	.000	.0116	.0013	.95	.94	1.99	" "
" "	July 1, 1895, to Dec. 1, 1895	.529	.152	—	—	.1480	.0034	1.08	—	2.91	" "
" "	Dec. 1, 1894, to Dec. 1, 1895	.402	.112	—	—	.0700	.0022	1.01	1.00	2.38	" "

TABLE XII.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1895 INCLUSIVE.

LOCATION.	Total Albuminoid Ammonia, 1893. Parts per 100,000.	Total Albuminoid Ammonia, 1894. Parts per 100,000.	Total Albuminoid Ammonia. 1895. Parts per 100,000.	Per Cent. Improvement, 1893-1894.	Per Cent. Improvement, 1894-1895.	Per Cent. Improvement, 1893 1895.	Total Oxygen Consumed, 1893. Parts per 100,000.	Total Oxygen Consumed, 1894. Parts per 100,000.	Total Oxygen Consumed, 1895. Parts per 100 000.	Per Cent. Improvement, 1893-1894.	Per Cent. Improvement, 1894-1895.	Per Cent. Improvement, 1893-1895.
WASHBURN & MOEN'S POND.												
December to July..........	—	.023	.032	—	-39.13	—	—	.74	.73	—	1.36	—
July to December..........	.052	.054	.050	-3.84	7.41	3.85	1.21	.87	1.14	28.10	-31.03	5.78
Average for year..........	.047	.037	.039	21.28	-5.41	17.02	1.03	.79	.90	23.30	-13.93	12.62
BLACKSTONE RIVER, BRIDGE.												
December to July..........	—	.047	.050	—	-6.38	—	—	.95	.96	—	-1.05	—
July to December..........	.085	.062	.056	27.06	9.68	34.11	1.40	.95	1.05	32.14	-10.52	25.00
Average for year..........	.103	.053	.052	48.56	1.89	49.51	1.51	.95	1.00	37.09	-5.26	33.77
BLACKSTONE RIVER, SWAMP.												
December to July..........	—	.129	.109	—	15.50	—	—	1.21	1.30	—	-7.44	—
July to December..........	.377	.178	.139	52.79	21.91	63.13	2.41	1.60	1.24	33.61	22.50	48.54
Average for year..........	.282	.150	.122	46.81	18.67	56.74	2.12	1.36	1.27	35.85	6.62	40.09
MORSE'S POND.												
December to July..........	—	.108	.093	—	13.89	—	—	1.17	1.15	—	1.71	—
July to December..........	.211	.157	.157	25.60	0.00	25.60	1.37	1.41	1.24	-2.92	12.05	9.47
Average for year..........	.175	.129	.120	26.29	6.98	31.43	1.43	1.27	1.19	11.19	6.29	16.78
ALDRICH'S POND.												
December to July..........	—	.101	.082	—	18.81	—	—	1.12	.95	—	15.18	—
July to December..........	.172	.151	.152	12.21	-0.66	11.63	1.18	1.27	1.08	-7.63	14.96	8.47
Average for year..........	.135	.122	.112	9.63	8.20	17.04	1.09	1.18	1.01	-8.26	14.41	7.34



Condition of the Blackstone River 1887-1896
from
Records of the Massachusetts State Board of Health
Diagram B.

THE NEW YORK
PUBLIC LIBRARY.

ASTOR, LENOX AND
TILDEN FOUNDATIONS.

TABLE XIII.

CONDITION OF BLACKSTONE RIVER BELOW SEWAGE PURIFICATION WORKS. FROM STATE BOARD OF HEALTH.

(Parts per 100,000.)

MONTHS.	Color.	Residue on Evap'ra'n.		Ammonia.				Chlorine.	Nitrogen As—		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dis-solved.	Sus-pended.				
June-November, 1887.....	0.91	——	—	.2686	.1741	——	——	1.35	.0160	——	—
" " 1888.....	0.76	——	—	.2658	.1112	.0557	.0555	1.50	.0382	.0041	—
" " 1889.....	0.86	——	—	.3960	.1430	.0772	.0658	1.82	.0177	.0026	—
" " 1890.....	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891.....	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892.....	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893.....	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894.....	0.40	29.30	5.86	.6189	13 90	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895.....	7.05	22.15	5.18	32.46	.0698	.0597	.0301	1.615	.0266	.0063	7.3

Note: This table is taken from Massachusetts State Board of Health records by permission.

[illegible]

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[illegible]		—	—	—
[illegible]		[illegible]	—	—
[illegible]	[illegible]	—	[illegible]	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] fall for September was much heavier in the centre of [illegible] owing to heavy showers which passed [illegible]

[illegible] for July began July 15.

ANNUAL REPORT

OF THE

Superintendent of Sewers,

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1896

Worcester, Mass.:
PRESS OF F. S. BLANCHARD & CO.,
34 FRONT STREET.
1897.

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ANNUAL REPORT

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To the Honorable City Council of the City of Worcester:

In compliance with Section 21, Chapter 34 of the City Ordinances, the following report of the work and condition of the Sewer Department for the fiscal year of 1896 is prepared.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

OFFICE OF THE SEWER DEPARTMENT,
December 1, 1896.

REPORT OF THE SUPERINTENDENT OF SEWERS.

CONSTRUCTION.

The department has been able to keep up with the petitions during the year and the number of requests for sewers now on file is not excessive. It would materially assist in the arrangement of the work if petitions were filed early in the year instead of being scattered along through the summer or coming in during the latter part of the fall. There are often unfavorable conditions which materially affect the quality and expense of construction, which, in many cases, can be overcome if anticipated early enough. Streams may be crossed and work done in wet localities during the summer months at much less expense than in the early spring or during freezing weather, while there are other localities in which work could be done as well during the latter seasons.

Surface water sewers are needed in several districts already provided with domestic sewers, and should be built as soon as the necessary funds are available.

The separate system has received considerable attention, and those sections of the city which are to be sewered on the combined plans have already been so well provided for that in the future comparatively little work will have to be done in them. Nearly all the districts not yet reached by trunk sewers can discharge surface water into streams near at hand.

In the report for 1895 it was stated that especial attention had been given to the refilling of trenches and that experiments were in progress to determine, upon both a laboratory and a practical scale, the differences in various methods and materials used in back filling. These experiments have been completed and the results are now being tabulated. They cover a variety of conditions and will give definite information upon the questions which in the past have been answered by conjecture only. This work will be completed early next year.

During the year the department has received $221,819.43, of which $128,135.84 have been expended. A large portion of the money appropriated for construction at the purification works will not be used until next year.

The following table will show the receipts and expenses of the various branches of the work for the year:

TABLE I.

SUMMARY OF FINANCIAL RESOURCES FOR 1896.

	Maintenance.	Construction.	Purification.	Order of 1896.
Balance Dec. 1, 1895,	$66 70	$1,987 37	$12,427 42	....
Appropriation,	17,000 00	30,000 00	30,000 00	$100,000 00
Assessments,	....	22,129 28	....	....
Revenue,	2,370 22	3,502 47	2,316 97*	19 00
Total,	$19,436 92	$57,619 12	$44,744 39	$100,019 00
Total expended,	18,295 60	42,076 91	43,264 23†	24,499 10
Balance Dec. 1, 1896,	$1,141 32	$15,542 21	$1,480 16	$75,519 90

* Received $2,163.70 from Law Department for legal expenses.

† A large portion of this amount has been expended on construction.

In the construction of a number of sewers rock has been encountered and the work of this kind has been in progress during the entire season. The steam drill has been in use almost constantly on this work, and has assisted in keeping the cost of rock excavation at a low figure, another instance of the advisability of owning labor saving machinery and having it ready for use without notice.

The trunk sewer to Bloomingdale has been completed at much less expense than was anticipated. Rock was encountered from the start to the finish and much of the way the grade required heavy cutting. The sewer built in Park avenue and Lovell street, from Beaver brook to Englewood avenue, provides for a large territory,upon which a considerable number of houses are now erected. This sewer was much needed and will greatly improve the district.

A table of stock used, together with the prices paid for the same, is herewith presented, as is also a brief schedule of the property owned by the department, and a table of the sewers constructed in the fiscal year of 1896, with statistics which may be of interest. The table of stock includes that used in the purification and maintenance departments as well as in construction.

TABLE II.

MATERIALS USED BY THE SEWER DEPARTMENT IN 1896.

Material.	Contractor.	PRICE PAID.		APPROXIMATE AMOUNTS USED.	
		1895.	1896.	1895.	1896.
Sand	William J. Lee,	$1.25	$1.00	454.5 cu. yd.	492.5 cu. yd.
Cement	Smith-Green Co.,	1.04	.99	1,994 bbls.	2,978 bbls.
Pipe	James Draper,	.....	.....	18,439.7 ft.	19,266.5 ft.
Brick	Norris C. Gault,	6.35	7.25	493,000	637,500
Lime	Smith-Green Co.,	5.75	5.50	3,243 tons	3,530 tons

SCHEDULE OF PROPERTY.

Personal property,	$25,417 52	
Hammond street, 1,700 feet of land,	425 00	
Disposal works, land,	9,300 00	
Buildings and machinery, East Worcester street,	2,765 00	
Buildings and machinery, disposal works,	8,055 00	
		$45,962 52

TABLE III.

Sewers Constructed During the Financial Year of 1896.

Street.	Location.	Size (Inches.)	Length (Feet.)	M. H.	Cost.
Barnard road,	Burncoat westerly,	10	279.0	2	$252 03
Dixon avenue,	Terminus southerly,	12	295.5	2	316 31
Sturgis,	Windsor to Uxbridge,	12	269.0	2	347 54
Putnam lane,	Through private land,	20x30 24x36	316.4 111.0	4	2,031 61
Putnam lane,	Through private land.	20x30	684.2	4	5,256 33
Plantation,	From new street to B. & A. R.R. bridge,	8 15	337.6 195.3	3	618 13
Rondeau court and Shale,	From Wall to north end of Shale,	8	673.9	7	1,734 95
Hamilton,	From terminus easterly,	8	410.2	2	263 18
Providence,	Union avenue southerly.	8	524.1	3	1,584 56
Arlington,	Union avenue southerly,	8	219.8	2	405 85
Fairbanks,	Ames northerly,	8	737.5	3	850 33
Whipple,	Millbury westerly,	16x24 24 round	1558.0 278.0	15	2,879 13
Southbridge (surface),	Crompton to Riverside,	12	162.8	2	247 01
Crompton and private land (surface),	Blackstone river to Brussels,	18 16x24	169.9 171.5	2	973 73
Brussels (surface),	Crompton westerly,	12	53.7	1	... .
West Fremont,	Webster to New York,	12	409.3	3	1,934 05
New York,	W. Fremont to Hope cemetery,	8	518.8	3	
Arbor Vitæ,	Main northerly,	8	464.9	4	348 64
Park avenue and Lovell,	Terminus in Park avenue to Englewood avenue,	8 15 round 15 oval	49.9 1540.7 962.0	19	3,994 49
Ferdinand,	Englewood avenue to Circuit avenue east,	8 15	763.0 28.8	7	930 60
Columbus,	Lovell to Circuit avenue east,	8	634.0	3	525 41
Oliver,	Birch southerly,	8	470.5	2	321 23
Freeland,	Terminus southerly,	8	170.0	1	168 60
Claremont square,	Main northerly,	8 10	416.9 31.0	4	777 31
Lagrange,	Jackson to Beacon,	8 12	272.9 427.6	6	723 95
Pleasant (surface),	Beaver brook through Newton square,	28x42	158.0	1	836 83
Newton avenue,	Pleasant to Midland,	20x30	357.6	3	1,867 93
Midland.	Newton avenue westerly,	10	605.2	3	631 96
Highland,	Terminus to Buffalo,	8 12 15	223.3 31.9 701.6	6	2,437 15
Buffalo,	Highland northerly,	8	229.4	2	161 97
Mount Hope,	Westland westerly,	8 12	188.5 89.2	3	266 92
Hampden,	Fruit easterly,	8 10	121.7 202.5	3	277 89
Berkshire,	Hampden northerly,	8	449.7	2	358.61

The buildings at the purification works and at the yard on East Worcester street are in good condition, but are poorly adapted to the uses for which they are intended. All the tools and machinery are in proper condition. The steam shovel recently purchased is doing excellent work and will doubtless prove to be a wise investment. This, with the railroad plant already owned by the department, will ensure good work at a minimum of expense.

As stated in the last report, a stable is much needed and this makes the necessity for increased yard room more apparent. Both should receive the early attention of the committee.

MAINTENANCE.

The continually increasing number of catch-basins requires a proportionate amount of cleaning. Each year a greater amount of refuse is removed and hauled longer and longer distances. This year 8,098 loads have been disposed of, an increase of 556 over the output for 1895. In spite of the difficulties attending this work, such as bailing water, handling twice, small loads and long hauls, the cost has amounted to but 61 cents per cubic yard, or 9 cents less than the cost per yard last year. This includes the cost of removing snow from the inlets to basins, and freeing basins stopped by ice or other obstacles. As has been stated in reports for years from this department, hundreds of dollars are spent in this way which could be saved by an adequate system of street maintenance.

The 100 miles of sewers require constant attention to prevent accumulation of deposits. The sewers large enough for men to work in are cleaned by shoveling the mud into boats or into pails. These are taken to the nearest man-hole, drawn up in buckets and hauled to the dumps. Those sewers which are too small to be cleaned in this way are scraped or flushed. The sewers which receive sewage only are flushed at frequent intervals from the hydrants in the streets to prevent stoppage and to keep them as clean as possible. A few automatic flush tanks have been put in, but these appliances have not been generally adopted.

Repairs are constantly being made and the sewer system is at the present time in very good condition. The Shrewsbury street sewer, although somewhat cracked, is thoroughly braced and has caused no trouble during the year. In the winter an examination will be made, and if there appears to have been much settlement it will probably be advisable to reconstruct a short portion of this sewer next season.

[illegible] OF [illegible]

[illegible]

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ing that a sludge pressing plant be erected. Immediately upon the receipt of this order steps were taken for carrying out its instructions, with the intention of having the presses running early in the fall. There was, however, some doubt as to the capability of the filter presses then on the market to press in a reasonable time the sludge produced here without the addition of considerable quantities of lime. As this would lead to large expense it was deemed advisable to get a standard press and to experiment with it to find out if it would do the work without lime, and if not, how much would have to be added.

These experiments have been completed and the press returned to the G. H. Bushnell Press Company, through whose courtesy it was obtained. Without going into the detail of the experiments it may be stated that certain modifications will be made in the construction of the presses which will ensure satisfactory pressing without the use of lime.

Filter presses consist of a number of thin iron plates properly supported on horizontal guides. These plates are dished on each side and are provided with drainage grooves, usually concentric, which deliver the filtered liquid to vertical grooves communicating with drip cocks on the outside of the press. Cloths cut to fit are placed on each side of each plate; the plates are then pushed together by means of a screw or hydraulic power. The joints are made water tight by the pressure of the ram. Each plate has a hole from four to six inches in diameter in the center, as have the cloths. The wet sludge is pumped into the press through one end, filling the spaces between the cloths, the water passing out by way of the drips. The solids are retained on the cloths, and when the press is full there is a thin cake of dry sludge between each pair of plates. Sludge dried in this way usually contains from 50 to 60 per cent. water. As considerable time was consumed in performing experiments and as a report was expected very soon from the experts who are studying the separating problem, it was deemed advisable to delay further construction on the pressing plant until their report was presented, as plans presented by them might possibly affect in some way this branch of the work.

PURIFICATION.

The methods of treatment of the sewage have remained the same as last year and an increased efficiency has resulted, 53.92 per cent. of the organic matter having been removed. This is the highest percentage removed in any year since the plant was started. About 3,500 tons of lime have been used. The amount of sewage treated has averaged about sixteen million gallons per day. The average amount of lime used per million gallons has been 1,212 pounds or 8.5 grains per U. S. gallon.

From the sewage 64,605,470 gallons of sludge or 1.1 per cent. of the flow have been removed. The sludge as pumped was 97.39 per cent. water and contained 7,025 tons of solids. Farmers have hauled about 5,500 two-horse loads of sludge containing about 75 per cent. water during the last twelve months. That there is some value to this material as a fertilizer is evident from the fact that the same farmers have used it several years in succession.

The comparative results of the treatment can be seen in Table IV. According to these averages of daily analyses the efficiency has steadily increased during the last four years, that being the time during which systematic chemical analyses have been made. In spite of the increased volume of sewage treated, the per cent. of suspended organic matter removed from the sewage is greater than last year.

Table V shows the results of treatment in the wet and dry seasons and gives some idea of the effect of surface water, although the comparatively constant outflow of water from North pond makes the difference less noticeable than it would otherwise be. It will be noticed that the average efficiency for the five months ending November 30 was higher by 3 per cent. than has been obtained before. For a sewage so dilute this result, 56.1 per cent. albuminoid ammonia removed, is very high, especially as it covers so long a period of time. It is easy to secure even 60 per cent. or 65 per cent. efficiency for a day, a week or even a month, but it is very difficult to get much over 51 per cent. or 52 per cent. removed during a series of months.

The per cent. of suspended matter removed, although 1 per cent. less than in 1894, is high, considering the flow.

The monthly averages of the composition of the sewage and effluent, together with the per cent. of the organic matter removed, can be studied in detail from Table VI. The diagram lettered A will be of assistance in such an examination. It is interesting as well as important to notice that the efficiency compares indirectly with the flow of the sewage; that is, with a given plant and sewage and a nearly uniform treatment, the per cent. of organic matter removed by chemical precipitation will vary, approximately, with the volume.

TABLE IV.

Per Cent. Organic Matter Removed from Sewage.

DESCRIPTION.	1893.	1894.	1895.	1896.
Total amount (by evaporation),	50.88	49.35	....	....
Amount in suspension (by evaporation),	90.67	94.45	....	....
Total amount (by albuminoid ammonia),	48.49	50.79	51.63	53.92
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11	92.02
Total amount (by oxygen consumed),	33.65	43.84	54.35	51.62
Amount in suspension (by oxygen consumed),	80.85	81.08	78.01	90.28

NOTE. — Although the determination of oxygen consumed has been made throughout the year, it is not considered as reliable as the determinations of albuminoid ammonia, because of large amounts of iron present in the sewage, and also because the determination itself is by no means as satisfactory as that for albuminoid ammonia.

TABLE V.

Per Cent. Organic Matter Removed from Sewage by Seasons.

DESCRIPTION.	DEC. TO JULY.			JULY TO DEC.			
	1894.	1895.	1896.	1893.	1894.	1895.	1896.
Total amount (by evaporation).	42.76	.....	.....	50.88	55.02	.....	.....
Amount in suspension (by evaporation),	93.08	.....	.....	90.67	95.76	.....	.....
Total amount (by albuminoid ammonia),	46.63	49.69	52.00	48.49	53.78	52.93	56.10
Amount in suspension (by albuminoid ammonia),	83.26	91.73	91.45	76.67	94.36	90.75	93.35
Total amount (by oxygen consumed),	37.11	46.92	50.78	33.65	50.23	61.08	53.15
Amount in suspension (by oxygen consumed),	89.27	82.96	.....	80.85	92.42	72.91	.....

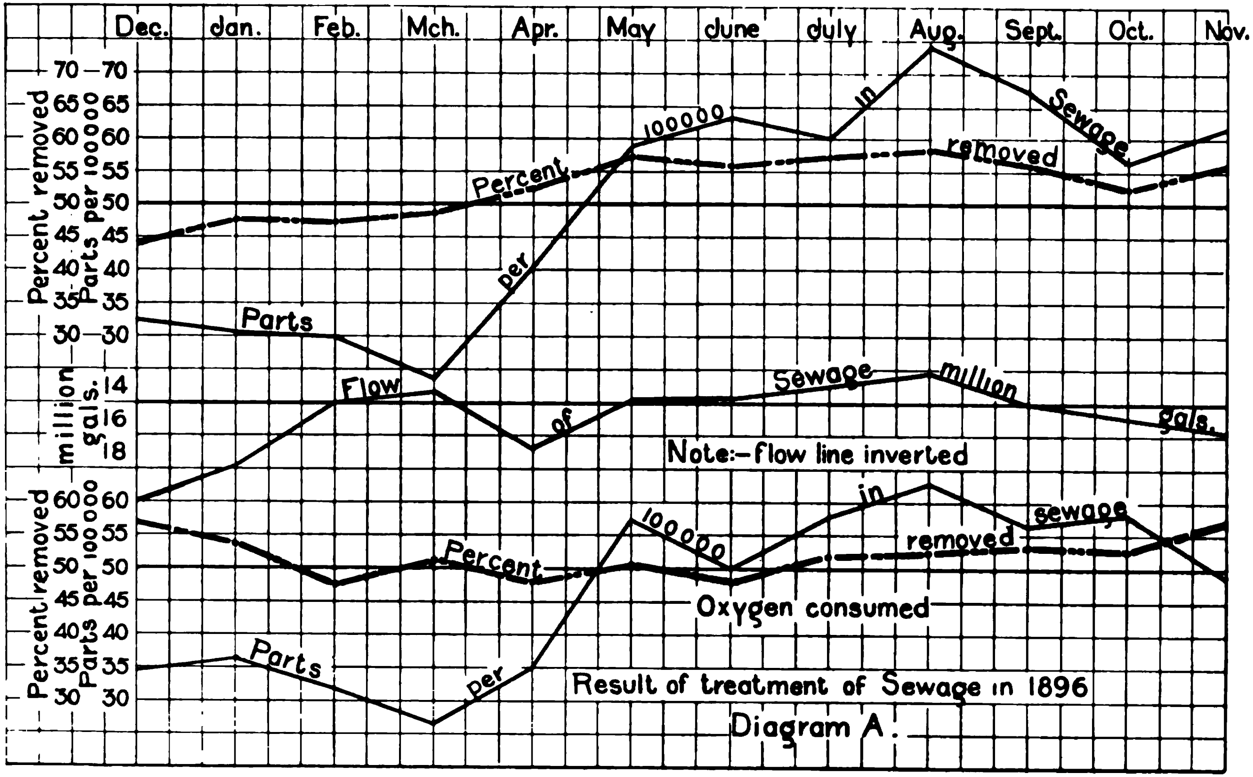
TABLE VI.

Monthly Averages of Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.
	Free.	ALBUMINOID.					
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	
Sewage, December, 1895	.593	.328	.160	.168	3.45	1.81	3.47
Effluent, " "	.545	.183	.163	.020	1.50	1.50	3.49
Parts removed	.048	.145	-.003	.148	1.95	.31	-.02
Per cent. removed	8.09	44.21	-1.88	88.10	56.52	17.13	-.58
Sewage, January, 1896	.756	.306	.148	.158	3.62	2.05	3.84
Effluent, " "	.706	.158	.148	.010	1.67	1.67	4.03
Parts removed	.050	.148	.000	.148	1.95	.38	-.19
Per cent. removed	6.62	48.37	00.00	93.67	53.87	18.54	-4.95
Sewage, February, 1896	.676	.300	.146	.154	3.15	2.02	3.69
Effluent, " "	.648	.158	.143	.015	1.66	1.66	3.62
Parts removed	.028	.142	.003	.139	1.49	.36	.07
Per cent. removed	4.14	47.33	2.06	90.00	47.30	17.82	1.90
Sewage, March, 1896	.470	.233	.113	.120	2.65	1.56	2.85
Effluent, " "	.434	.119	.102	.017	1.29	1.29	2.77
Parts removed	.036	.114	.011	.103	1.36	.27	.08
Per cent. removed	7.66	48.93	9.73	85.82	51.33	17.31	2.81
Sewage, April, 1896	1.000	.409	.216	.193	3.49	2.05	4.53
Effluent, " "	.896	.195	.182	.013	1.81	1.81	4.52
Parts removed	.104	.214	.034	.180	1.68	.24	.01
Per cent. removed	10.40	52.32	15.74	93.28	48.14	11.70	.22
Sewage, May, 1896	1.604	.592	.293	.299	5.75	3.10	6.38
Effluent, " "	1.480	.252	.233	.019	2.82	2.82	6.39
Parts removed	.124	.340	.060	.280	2.93	.28	-.01
Per cent. removed	7.73	57.43	20.14	93.65	50.96	9.03	-.15
Sewage, June, 1896	1.468	.632	.330	.302	5.04	3.15	6.61
Effluent, " "	1.407	.279	.251	.028	2.62	2.62	6.61
Parts removed	.061	.353	.079	.074	2.42	.53	0.00
Per cent. removed	4.15	55.85	23.94	90.73	48.02	16.83	00.00
Sewage, July, 1896	1.402	.602	.318	.284	5.77	3.05	7.11
Effluent, " "	1.273	.255	.238	.017	2.79	2.79	7.09
Parts removed	.129	.347	.080	.267	2.98	.26	02
Per cent. removed	9.20	57.63	25.16	94.01	51.64	8.52	00.28
Sewage, August, 1896	1.603	.743	.345	.398	6.30	3.08	8.01
Effluent, " "	1.466	.308	.282	.026	3.01	3.01	8.04
Parts removed	.137	.435	.063	.372	3.29	.07	-.03
Per cent. removed	8.55	58.55	18.26	93.46	52.23	2.27	-.37
Sewage, September, 1896	1.331	.677	.320	.357	5.64	2.65	6.83
Effluent, " "	1.119	.297	.267	.030	2.64	2 64	6.86
Parts removed	.212	.380	.053	.327	3 00	.01	-.03
Per cent. removed	15.93	56.13	16.56	91.60	53.37	00.37	-.44
Sewage, October, 1896	1.238	.565	.272	.293	5.84	2.63	6.65
Effluent, " "	1.037	.271	.249	.022	2.75	2.75	6.71
Parts removed	.201	.294	.023	.271	3.09	-.12	-.06
Per cent. removed	16.23	52.04	8.46	92.49	52.91	-2.91	-.90
Sewage, November, 1896	1.257	.613	.295	.318	4.94	2.49	6.18
Effluent, " "	1.106	.271	.255	.016	2.14	2.14	6.17
Parts removed	.151	.342	.040	.302	2.80	.35	.01
Per cent. removed	12.01	55.78	13.56	94.97	56.69	14.06	00.16
Sewage for year ending Dec. 1, 1896	1.118	.497	.246	.251	4.63	2.47	5.50
Effluent " " " "	1.012	.229	.209	.020	2.23	2.23	5.53
Parts removed	.106	.268	.037	.231	2.40	.24	-.03
Per cent. removed	9.48	53.92	15.04	92.02	51.62	9.72	-.54

NOTE.—Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of sampling. Effluent samples consist of twenty-four portions taken hourly.



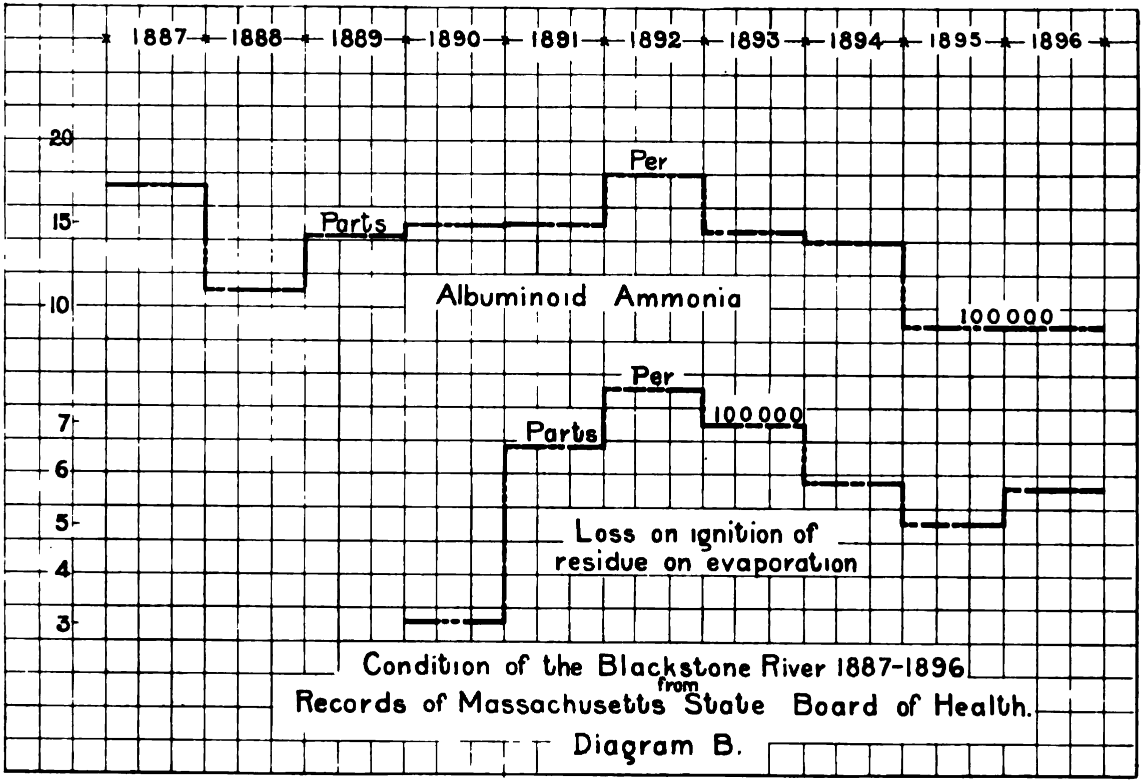
Result of treatment of Sewage in 1896
Diagram A.

TABLE VII.

AVERAGES OF WEEKLY ANALYSES OF WATER FROM THE BLACKSTONE RIVER FROM DECEMBER, 1895, TO JULY, 1896; JULY, 1896, TO DECEMBER, 1896, AND FROM DECEMBER, 1895, TO DECEMBER, 1896.

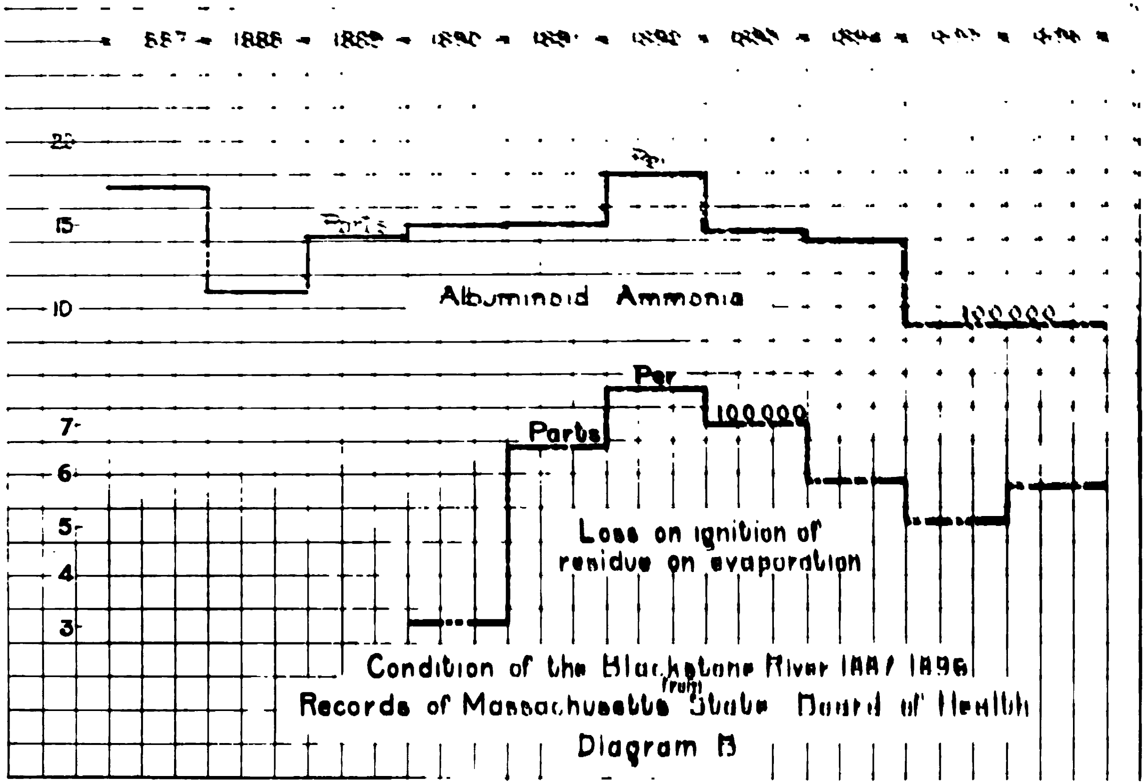
(Parts per 100,000.)

WHERE TAKEN.	DATE OF COLLECTION.	Free Ammonia	Total Albuminoid Ammonia	NITROGEN AS		Total Oxygen Consumed	Chlorine.
				Nitrates	Nitrites.		
Washburn & Moen pond	Dec. 1, 1895, to July 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " "	July 1, 1896, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " "	Dec. 1, 1895, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bridge	Dec. 1, 1895, to July 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	July 1, 1896, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Dec. 1, 1895, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Swamp	Dec. 1, 1895, to July 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	July 1, 1896, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Dec. 1, 1895, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Morse pond	Dec. 1, 1895, to July 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	July 1, 1896, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	Dec. 1, 1895, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aldrich pond	Dec. 1, 1895, to July 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	July 1, 1896, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	Dec. 1, 1895, to Dec. 1, 1896,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Condition of the Blackstone River 1887-1896
Records of Massachusetts State Board of Health.
from

Diagram B.



Condition of the Blackstone River 1887 1896
Records of Massachusetts (from) State Board of Health
Diagram B

TABLE IX.

Condition of Blackstone River Below Sewage Precipitation Works. From State Board of Health.

Parts per 100,000.

MONTHS.				Residue on Evaporation.		Ammonia.					Nitrogen as		
							Albuminoid.						
			Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
June-November,		1887........	[illegible]		-	[illegible]	[illegible]	....	....	[illegible]	[illegible]	....	....
"	"	1888..........	0.76	....	...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	....
"	"	1889... ..	0.56	....	....	[illegible]	[illegible]	.0772	[illegible]	[illegible]	[illegible]	[illegible]	....
"	"	1890......	[illegible]	[illegible]	2.10	[illegible]	[illegible]	[illegible]	.0770	[illegible]	[illegible]	[illegible]	[illegible]
"	"	1891..... ...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	1892....	0.63	[illegible]	7.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	1893.......	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	1894........	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.68	[illegible]	[illegible]	[illegible]
"	"	1895..........	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	"	1896.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.10	[illegible]	[illegible]	[illegible]

NOTE.—This table is taken from Mass. State Board of Health Reports by permission.

ANNUAL REPORT

OF THE

SUPERINTENDENT OF SEWERS

OF THE

CITY OF WORCESTER

FOR THE

YEAR ENDING NOVEMBER 30, 1897.

WORCESTER, MASS.:
PRESS OF CHARLES HAMILTON,
311 MAIN STREET.
1898.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.
1900.

ANNUAL REPORT

OF THE

SUPERINTENDENT OF SEWERS

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1897.

WORCESTER, MASS.:
PRESS OF CHARLES HAMILTON
311 MAIN STREET.
1898.

To the Honorable City Council of the City of Worcester:—

In compliance with Section 21, Chapter 34 of the City Ordinances, the following report of the work and condition of the Sewer Department for the fiscal year of 1897 is prepared.

Respectfully submitted.

HARRISON P. EDDY,

Superintendent of Sewers.

OFFICE OF THE SEWER DEPARTMENT,
December 1, 1897.

MEMBERS OF THE COMMITTEE ON SEWERS, 1897.

President of the Board of Aldermen **Edward M. Woodward**,
Chairman, ex-officio.

Alderman **Enoch Earle**, Alderman **William A. Lytle**,
President of the Common Council **Frank B. Hall**,
Councilman **George S. Hatch** (January 4 to May 10),
Councilman **Bernard H. McMahon** (May 10 to end of year),
Councilman **Frederick W. White**,
Councilman **Albert M. Powell**.

ANNUAL REPORT

OF THE

SUPERINTENDENT OF SEWERS.

CONSTRUCTION.

The regular sewer construction has not been as important during the year as the work upon the separating system. Nearly all the sewers petitioned for were ordered early in July and were built before fall. Very few petitions are now in the hands of the Committee on Sewers, and the number received and referred to the next City Council is not large.

The rule adopted by the City Council that petitions must be presented on or before July 1 if to be acted upon during the year, has been of great assistance to the department. It has made it possible to lay out the year's work to far greater advantage than had been possible in the past and it has assisted in the economical construction of work ordered.

At present there are no expensive sewers known to be greatly needed, and, so far as can be seen, this work will not occupy the department for a very large portion of the coming year, so that it will be possible to concentrate the entire force upon the construction of the separating system.

There are several orders on file for sewers which have not been constructed. One of these is for a surface water sewer in West Fremont Street, which will discharge into the river at the bridge recently constructed by the Street Department. This sewer was ordered on petition from the Commissioners of Hope Cemetery, but at their request was not constructed, as they found relief by another method. There is need of a surface water sewer in this district, however, and the sewer should be built next year. It was not deemed advisable to construct it this year, as it would have to be laid in the new embankment, which would probably settle and injure any construction in it. Orders are also on file for sewers in Vinton, Gilman and Lyford Streets. When these orders were made out it was expected that a new street would extend from Harlow Street to Lyford Street at the foot of the hill, and that an outlet might be had through this street to the Harlow Street sewer. It has since been learned that no such street will be built, and these sewers cannot be built until an outlet is provided.

Several orders for work on the separating system are on file, but no more than necessary to keep the work going from one meeting of the City Council to the next.

Several surface water sewers which have been much needed in the past have been built. The one in the Vernon Street district, discharging into the Blackstone River, will be of great assistance in maintaining the street in proper condition, as it enables this department to provide the necessary catch-basins. These having been provided and the gutters of Vernon Street paved, there should be little trouble from surface water hereafter. The extension of the surface water sewer in Pleasant Street will also prove of much assistance in the maintenance of that street.

SEPARATING SYSTEM.

The separating system, which has been under consideration for a long time, has been well started during this year. After the report of the city was filed in court, the City Council petitioned the legislature for leave to borrow the money which will be required for constructing this system. As soon as such leave was granted orders were passed for beginning the work, which was commenced as soon as possible thereafter. This work has been pushed as rapidly as possible and very much has been accomplished. The work inside of the Millbrook sewer has been more difficult than any other portion of this system yet undertaken. For the building of this conduit special machines had to be purchased and considerable time was expended in preliminary work, but at the present time this work is much more than half done, and, unless prevented by the weather, it should be finished early next year.

The South Worcester section, in the vicinity of Cambridge Street, has been almost completely re-sewered, and as soon as a short section of the trunk sewer is constructed under the Norwich & Worcester railroad tracks all of the surface water from this district will be diverted from the sewer system and turned directly into Stillwater Pond.

On the west side, from Main Street to Park Avenue near Maywood Street, and from Woodland Street to Park Avenue, sewers have been constructed which will convey surface water from this part of the city directly into Beaver Brook. It is hoped to complete all of the work in this part of the city during the coming year.

During the year the department has received $413,241.13, of which $225,772.22 have been expended. Table I. shows the expense and receipts of the year for the various branches of the work. Table II. gives an account of the stock used, together with the prices paid for the same, and includes that used at the purification works and in the maintenance department as well as construction. Table III. gives the sewers constructed during the fiscal year of 1897, and is divided into two parts, the first being of the sewers constructed and charged to the regular construction account, and the second the sewers constructed and charged to the account of the separating system. In all, 9.32 miles of sewers have been constructed, together with 375 manholes and 95 catch-basins. The sewers may be subdivided as follows: Sanitary sewers, 1.85; combined sewers, 1.80 miles; surface water drains, 2.15 miles; and in the separating system, sanitary sewers, .44 mile; surface water drains, 3.80 miles. Sewers built in ordinary construction, 5.80 miles; and in the separating system, 3.52 miles. Of the 9.32 miles of sewers constructed, 2.14 miles are trunk sewers. The number of permits issued during the year is 410, of which 5 were not used, 7 were for repairs, and 5 for surface water, leaving 393 sanitary drains constructed.

TABLE I.

SUMMARY OF FINANCIAL RESOURCES FOR 1897.

	Maintenance.	Construction.	Order of 1896 Purification.	Statutes of 1897.
Balance Dec. 1, 1896,	$1,141 42	$15,542 21	$77,000 06	. . . . . .
Appropriation,	17,000 00	30,000 00	35,000 00	$200,000 00
Assessments,	. . . .	22,426 70	. . . . . .	. . . .
Revenue,	2,428 78	12,500 75	168 89	18 42
Total,	$20,570 10	$80,469 66	$112,168 95	$200,018 42
Total expended,	16,932 84	61,863 06	89,669 74	57,292 58
Balance Dec. 1, 1897.	$3,637 26	$18,606 60	$22,499 21	$142,725 84

TABLE II.

MATERIALS USED BY THE SEWER DEPARTMENT IN 1897.

Material.	Contractor.	Price Paid.			Approximate Amounts Used.		
		1895.	1896.	1897.	1895.	1896.	1897.
Sand,	Amos M. Eaton, Estate,	$1.25	$1.00	$0.90	454.5 cu. yds.	492.5 cu. yds.	1,819.5 cu. yds.
Portland cement,	Benjamin F. Marsh,	. . .	. . .	2.15	. . . .	. . . .	3,260 bbls.
Rosendale cement,	Benjamin F. Marsh,	1.04	.99	.86	1,994 bbls.	2,978 bbls.	6,894 bbls.
Pipe,	James Draper,	. . .	. . .	. . .	18,439.7 ft.	19,266.5 ft.	36,565.3 ft.
Brick,	Wilson A. Spiers,	6.35	7.25	7.20	493,000.	637,500.	2,653,100.
Lime,	Frank E. Powers,	5.75	5.50	4.99	3,243 tons.	3,530 tons.	3,776 tons.

TABLE III.

TABLE OF SEWERS CONSTRUCTED DURING THE FINANCIAL YEAR OF 1897.

SURFACE SEWERS.

Street.	Location.	Size (Inches.)	Length (Feet.)	M. H.	Cost.
Vernon,	Ballard avenue to Upsala,	20x30 18x27 15	350.8 110.0 1140.1	15	
Esther,	Vernon to Upsala,	15 12	600.5 787.3	9	
Esther,	Vernon to Henrietta,	12	350.3	3	
Louise,	Vernon easterly,	12	30.7	1	$5,446 46
Douglas,	Cambridge northerly,	10	429.9	3	
Cambridge,	Camp to Douglas,	12	101.4	2	538 41
Camp,	Cambridge northerly,	10	478.9	4	467 61
Camp,	Stillwater Pond to Cambridge,	24x36	1049.2	8	
Cambridge,	Camp to South Crystal,	24x36 16x24	229.4 850.4	8	
South Crystal,	Cambridge to Crystal,	15	549.4	4	
Crystal,	South Crystal to Illinois,	12	172.2	2	
Hacker,	Cambridge to Southgate,	18 oval 15	227.2 498.3	4	6,802 15
Southgate,	Hacker to Camp,	10	818.0	3	238 34
Southgate,	Hacker to King's Court,	12	539.0	5	442 88
Litchfield,	Hacker westerly,	10	263.2	3	185 57
Cambridge,	South Crystal to Fremont,	12 10	78.4 405.7	4	
Fremont,	Cambridge southwesterly,	10	210 3	1	467 17
Illinois,	Crystal to Richards,	12 10	19.1 526.2	5	443 73
Richards,	Main southeasterly,	12	504.5	3	461 94
Waller avenue,	Blackstone river to Cambridge,	24 round 16x24	425.1 223 0	3	
Cambridge,	Waller avenue easterly,	16x24 18 oval	202.1 822.2	3	1 226 45
Main,	Maywood to Downing,	18 oval 16 oval	202.7 572.3	6	1,138 62
Main,	Montague westerly,	15 12	376.8 418.0	6	
Main,	Gates Lane to Sylvan,	16x24	821.9	4	1,854 63
Downing,	Main to Woodland,	12	462.5	6	607 52
Woodland,	Downing to Charlotte,	12	289.0	3	496 33
Hollywood,	Oberlin northerly,	12	147.9	3	
Florence,	Maywood to Downing,	12	806.8	6	574 29
Florence,	Maywood to Beaver,	12	553.9	4	414 87
Birch,	Maywood southerly,	10	303.7	3	405 80
May,	Park avenue to Clifton,	15 12 10	339.4 324.4 123.4	7	747 01
Kingsbury,	Parker to Hollywood,	15 12	96.6 319.1	4	533 06
Page,	Parker to Decatur,	12	149.0	2	243 56
Park avenue,	Parker to Downing,	24x36 20x30 30 15	750.1 778.4 39.0 376.0	12	
Park avenue,	Parker to Tufts,	15 12	225.7 202.9	3	
Tufts,	Park avenue easterly,	12	495.3	4	
Parker,	Beaver Brook to Park avenue,	39	949.5	7	
May,	Park avenue westerly,	12	48.9	1	7,831 11
May,	Beaver Brook northwesterly,	18 15	306.2 677.9	5	
Winfield,	Parker northerly,	12	298.2	3	
Pleasant,	Newton square to Beeching,	28x42 24x36 20x30 16x24	1129.5 621.6 386.1 680.3	16	6,792 16
Salisbury,	Salisbury pond northwesterly,	30 22x33 20x30	43.2 461.8 721.0	10	2,193 93

NOTE: The sewer in May street, Beaver brook, northwesterly, was constructed by the Highway Department.

SANITARY SEWERS.

Street.	Location.	Size (Inches)	Length (Feet.)	M.H.	Cost.
Main	Walnut to Sudbury	10	110.5	2	$344 45
Burncoat	Terminus northerly	15 12	352.3 687.0	8	3,796 17
Forbes	Lincoln to Westminster	10 8	45.7 267.9	3	526 51
Orne	Lincoln to Westminster	10 8	54.1 270.3	2	388 53
Orne	Paine to Lincoln	8	218.8	2	190 88
Belvidere avenue	Burncoat easterly	8	388.0	2	1,454 74
Olive avenue	Burncoat easterly	8	863.0	3	668 13
Ashton	Washington avenue northerly	15	34 7	1	48 70
Windsor	Sturgis to Green lane	8	143.7	2	150 89
Catharine	Hermitage brook to Channing	15	490.6	4	
Channing	Catharine to Harrington avenue	15	334.0	3	982 99
Henchman ct.	Henchman to Frederick st. extension	12	243.2	3	
Frederick	Henchman ct. easterly	12 8	120.6 156.1	4	572 43
Merrifield	Elliott northerly	8	292.6	2	289 87
Wilson	Seward westerly	8	176.5	3	280 24
Hunt	Shrewsbury southerly	8	274.4	3	591 91
Adams	Terminus to Belmont	18 x 27 16 x 24	244.6 805.2	7	
Belmont	Adams westerly	16 x 24	217.4	2	2,229 57
Liscomb	Shrewsbury northerly	8	330.1	3	394 51
Bloomingdale road	From M. H. No. 7 to No. 8	36 x 54	211.5	1	1,245 18
Norfolk	Wall easterly	10 8	494.0 1179.0	10	2,252 63
Chrome	Wall to Orient	9	351.2	3	364 85
Henrietta	Esther to Maxwell	8	404.7	4	447 15
Ashmont ave.	Quinsigamond avenue to South Harding	8	527.3	4	663 09
Lagrange	Main southeasterly	9	226.1	3	284 47
Illinois	Crystal northeasterly	10 8	43 0 408.6	3	428 78
Gates	Illinois northwesterly	12 8	434.8 323.5	6	621 16
Hollis	Grand southwesterly	12	294.4	3	357 93
Cambridge	Duncan avenue to Sutton lane	8	694.6	6	
Sutton lane	Cambridge to B. & A. R. R.	8	245.8	2	1,188 84
Woodland	Maywood northeasterly	12	41.9	2	79 89
Charlotte	Park avenue to Florence	10	705.8	6	
Florence	Charlotte to Oberlin	10	464.2	4	
Oberlin	Florence to Hollywood	10 9	261.9 315 5	6	2,917 88
Florence	Shirley to Charlotte	8	603 8	3	452 14
Coes	Park avenue westerly	8	1216.9	8	884 12
Mason st. ct.	Mason westerly	8	165.4	2	115 51
Parker	Park avenue to Bradford	10	526.4	3	
Circuit ave. east	Columbus to Cabot	8	152.4	2	142 83
Englewood avenue	Ferdinand to Isabella	15	333.4	2	
Isabella	Englewood avenue to Circuit avenue east	8	622.4	5	788 09
Shawmut	Russell easterly	9	153.7	2	174 64
Chamberlain pl.	Pleasant northerly	9	244.6	2	323 96
Einhorn road	Highland to Institute road	12 8	33.0 768.8	5	716 96
Trowbridge road	Highland to Institute road	12 8	45.0 694.8	5	765 75
Schussler road	Highland to Institute road	12 8	43.9 641.0	5	588 59
Highland	Terminus to Schussler road	12	110 4	1	
Private st.	Boynton to West	8	471.9	4	262 96

Following is a brief schedule of the property owned by the Department: —

Personal property,	$31,741 35
Hammond street, 1,700 feet of land,	425 00
Disposal works, land,	34,300 00

Buildings and machinery, East Worcester street,	2,812 00	
Buildings and machinery, disposal works,	11,720 73	
		$80,999 08

The buildings at the Purification Works are in fairly good condition. At East Worcester street the building used as a shop is in poor condition, the floor having fallen through several times during the past year. All tools and machinery are in proper condition.

RECOMMENDATIONS.

1. That a stable be erected as soon as possible at the headquarters on East Worcester street.
2. That the shop be repaired or in part rebuilt during the present winter.
3. That more yard room be provided at once.
4. That several new horses and wagons be purchased before Spring.
5. That the ordinances be modified to conform to the plan adopted for a separate system of sewers.
6. That the ordinances be modified so as to prevent any possibility of the discharge of steam into sewers.

PURIFICATION.

The treatment of the sewage has been carried on throughout the year substantially as in the past. The volume of sewage received at the precipitation works has increased to an average of seventeen million gallons per day of twenty-four hours. The sewage, while not so strong as in 1896, has been stronger in proportion to the flow. From the analyses, which have been daily as in former years, it appears that 53.02 per cent. of the organic matter in the sewage has been removed. This is nearly one per cent. less than in 1896, and may be accounted for partly, at least, by the increased flow. About 3,700 tons of lime have been used in the treatment, which would average 1,130 pounds per million gallons, or 7.9 grains per U. S. gallon.

The sludge produced has been disposed of, as in the past, by being turned onto the land and dried by filtration and evaporation. During the year, 66,557,365 gallons of sludge have been pumped from the settling basins. This amounts to 1.7 per cent. of the flow of sewage, and when pumped contains about 97.39 per cent. water. The total amount of dry solids removed from the sewage in this way was 7,237 net tons. The demand for sludge to be used for fertilizer has increased during the year, 6,350 two-horse loads having been drawn onto neighboring farms by the farmers themselves. This is an increase of 850 loads over that taken in 1896. The sludge drawn away contained on the average 75 per cent. moisture, and the average load would weigh at least 3,000 pounds.

The results of the treatment from year to year may be compared in tables IV. and V. It will be noticed that the results shown in table IV. indicate that the treatment has not been quite as efficient during 1897 as in 1896, but that it was better than in the years previous to 1896.

TABLE IV.

Per Cent. Organic Matter Removed from Sewage.

DESCRIPTION.	1893.	1894.	1895.	1896.	1897.
Total amount (by evaporation)........	50.88	49.35	....	....	....
Amount in Suspension (by evaporation)........	90.67	94.45	....	....	....
Total amount (by albuminoid ammonia)........	48.49	50.79	51.63	53.92	53.02
Amount in suspension (by albuminoid ammonia).	76.67	89.54	91.11	92.02	93.46
Total amount (by oxygen consumed)........	33.65	43.84	54.35	51.62	52.00
Amount in suspension (by oxygen consumed).....	80.85	81.08	78.01	....	....

NOTE.—Although the determination of oxygen consumed has been made throughout the year, it is not considered as reliable as the determinations of albuminoid ammonia, because of large amounts of iron present in the sewage, and also because the determination itself is by no means as satisfactory as that for albuminoid ammonia.

TABLE V.

Per Cent. Organic Ma[illegible] R[illegible]

DESCRIPTION	December to July				July to December				
	1894	1895	1896	1897	1893	1894	1895	1896	1897
Total amount (by evaporation)	[illegible]				[illegible]	[illegible]			
Amount in suspension (by evaporation)	[illegible]				[illegible]	[illegible]			
Total amount (by albuminoid ammonia)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Amount in suspension (by albuminoid ammonia)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total amount (by oxygen consumed)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Amount in suspension (by oxygen consumed)	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		

The monthly averages of the composition of the sewage and effluent, together with the per cent. of the organic matter removed, can be studied in detail from Table VI. It is interesting as well as important to notice that the efficiency compares in inverse ratio with the flow of the sewage.

CONDITION OF THE BLACKSTONE RIVER.

There is little change in the condition of the Blackstone River to report this year. According to the monthly analyses of this water, made by the State Board of Health, the pollution has been greater than in 1896, while the weekly analyses made by this Department would indicate an improvement from Washburn & Moen's pond to Aldrich's pond in Millbury. The improvement, while not very great, appears to be steady from year to year. Tables VII., VIII., and IX., the latter of which is compiled from the records of the State Board of Health, contain the results of this year's analyses and averages of analyses of several years past.

TABLE VI.

Monthly Averages of Analyses of Sewage and Effluent.

(Parts per 100,000.)

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.
	Free.	ALBUMINOID.					
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	
Sewage, December, 1896	1.027	.483	.236	.247	4.20	2.22	6.07
Effluent, " "	.879	.260	.245	.015	2.20	2.20	6.09
Per cent. removed	14.42	46.17	-3.81	93.93	47.62	0.91	-0.33
Sewage, January, 1897	1.061	.472	.235	.237	3.85	2.22	5.82
Effluent, " "	.931	.259	.224	.035	2.19	2.19	5.87
Per cent. removed	12.26	45.13	4.68	85.25	43.11	1.35	-0.86
Sewage, February, 1897	.960	.445	.243	.202	4.61	2.49	5.71
Effluent, " "	.853	.229	.221	.008	2.26	2.26	5.77
Per cent. removed	11.69	48.54	9.01	96.04	50.87	9.24	-1.05
Sewage, March, 1897	.505	.256	.149	.107	3.03	1.79	3.60
Effluent, " "	.471	.132	.126	.006	1.53	1.53	3.75
Per cent. removed	6.73	48.44	15.44	93.44	49.51	14.52	-4.26
Sewage, April, 1897	.796	.321	.171	.150	3.51	1.99	4.62
Effluent, " "	.694	.179	.169	.010	2.00	2.00	4.64
Per cent. removed	12.81	44.24	1.17	93.33	43.02	-0.50	-0.43
Sewage, May, 1897	1.077	.428	.196	.232	3.96	1.81	5.64
Effluent, " "	.915	.202	.181	.021	1.90	1.90	5.70
Per cent. removed	15.04	52.81	7.65	90.95	52.02	-4.97	-1.06
Sewage, June, 1897	1.220	.491	.229	.262	4.31	2.05	6.23
Effluent, " "	1.089	.215	.198	.017	1.94	1.94	6.27
Per cent. removed	9.10	56.20	13.54	93.53	54.98	5.37	-0.64
Sewage, July, 1897	1.206	.486	.227	.259	3.75	1.71	6.39
Effluent, " "	1.095	.206	.189	.017	1.58	1.58	6.38
Per cent. removed	9.35	57.62	16.67	93.34	57.88	7.02	0.16
Sewage, August, 1897	1.137	.648	.306	.342	4.40	1.75	6.59
Effluent, " "	1.063	.261	.248	.013	1.72	1.72	6.54
Per cent. removed	6.50	59.71	18.95	96.20	60.89	1.72	0.76
Sewage, September, 1897	1.457	.588	.308	.280	4.75	2.19	7.09
Effluent, " "	1.399	.263	.245	.018	1.92	1.92	7.07
Per cent. removed	3.98	55.27	20.45	93.57	59.58	12.33	0.30
Sewage, October, 1897	1.724	.621	.279	.342	5.57	2.78	6.84
Effluent, " "	1.583	.252	.241	.011	2.65	2.65	6.83
Per cent. removed	8.18	59.42	13.62	96.79	52.42	4.67	0.15
Sewage, November, 1897	1.108	.491	.224	.267	4.89	2.46	5.88
Effluent, " "	1.000	.225	.201	.024	2.44	2.44	5.79
Per cent. removed	9.75	54.18	10.27	90.00	50.10	0.82	1.53
Sewage for year ending Dec. 1, 1897	1.108	.478	.233	.245	4.23	2.12	5.87
Effluent, " " " " " " "	1.001	.224	.208	.016	2.03	2.03	5.89
Per cent. removed	9.66	53.02	10.75	93.46	52.00	4.25	-0.34

NOTE.—Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at time of sampling. Effluent samples consist of twenty-four portions taken hourly.

TABLE VII.

AVERAGES OF WEEKLY ANALYSES OF WATER FROM THE BLACKSTONE RIVER FROM DECEMBER, 1896, TO JULY, 1897; JULY, 1897, TO DECEMBER, 1897; AND FROM DECEMBER, 1896, TO DECEMBER, ·1897.

(Parts per 100,000.)

WHERE TAKEN.	DATE OF COLLECTION.	Free Ammonia.	Total Albuminoid Ammonia.	NITROGEN AS		Total Oxygen Consumed.	Chlorine.
				Nitrates.	Nitrites.		
Washburn and Moen Pond . . .	Dec. 1, 1896, to July 1, 1897 . .	.012	.022	.010	.0005	0.59	0.55
" " " " . . .	July 1, 1897, to Dec. 1, 1897 . .	.025	.037	.019	.0008	0.67	0.62
" " " " . . .	Dec. 1, 1896, to Dec. 1, 1897 . .	.017	.028	.014	.0006	0.62	0.58
Bridge	Dec. 1, 1896, to July 1, 1897 . .	.051	.037	.018	.0018	0.74	0.88
"	July 1, 1897, to Dec. 1, 1897 . .	.140	.048	.026	.0013	1.08	1.25
"	Dec. 1, 1896, to Dec. 1, 1897 . .	.089	.042	.022	.0013	0.88	1.08
Swamp	Dec. 1, 1896, to July 1, 1897 . .	.206	.085	.030	.0034	0.89	1.99
"	July 1, 1897, to Dec. 1, 1897 . .	.466	.127	.036	0071	1.24	2.79
"	Dec. 1, 1896, to Dec. 1, 1897 . .	.316	.103	.032	.0049	1.04	2.33
Morse Pond	Dec. 1, 1896, to July 1, 1807 . .	.231	.082	.025	.0029	0.92	2.10
" "	July 1, 1897, to Dec. 1, 1897 . .	.562	.119	.031	.0060	1.07	2.96
" "	Dec. 1, 1896, to Dec. 1, 1897 . .	.371	.098	.028	.0042	0.98	2.46
Aldrich Pond	Dec. 1, 1896, to July 1, 1897 . .	.210	.074	.021	.0028	0.79	1.86
" "	July 1, 1897, to Dec. 1, 1897 . .	.503	.108	.034	.0066	0.85	2.57
" "	Dec. 1, 1896, to Dec. 1, 1897 . .	.349	.089	.027	.0044	0.81	2.16

TABLE VIII.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1897 INCLUSIVE.

LOCATION.	Total Albuminoid Ammonia, 1893. Parts per 100,000.	Total Albuminoid Ammonia, 1894. Parts per 100,000.	Total Albuminoid Ammonia, 1895. Parts per 100,000.	Total Albuminoid Ammonia, 1896. Parts per 100,000.	Total Albuminoid Ammonia, 1897. Parts per 100,000.	Per Cent. Improvement, 1893-1894.	Per Cent. Improvement, 1894-1895.	Per Cent. Improvement, 1895-1896.	Per Cent. Improvement, 1896-1897.	Per Cent. Improvement, 1893-1897.	Total Oxygen Consumed, 1893. Parts per 100,000.	Total Oxygen Consumed, 1894. Parts per 100,000.	Total Oxygen Consumed, 1895. Parts per 100,000.	Total Oxygen Consumed, 1896. Parts per 100,000.	Total Oxygen Consumed, 1897. Parts per 100,000.	Per Cent. Improvement, 1893-1894.	Per Cent. Improvement, 1894-1895.	Per Cent. Improvement, 1895-1896.	Per Cent. Improvement, 1896-1897.	Per Cent. Improvement, 1893-1897.
WASHBURN & MOEN'S POND.																				
December to July.	......	.023	.032	.025	.022	......	-39.13	21.25	12.00	......	......	.74	.75	.64	.59	......	1.35	12.33	7.81	......
July to December,	.052	.054	.050	.042	.037	-3.84	7.41	16.00	11.91	28.85	1.21	.87	1.14	.64	.67	28.10	-31.03	43.86	-4.69	44.63
Average for Year,	.047	.037	.039	.032	.028	21.28	-5.41	17.95	12.50	40.42	1.03	.79	.90	.64	.62	23.30	-13.93	28.89	3.11	39.81
BLACKSTONE RIVER, BRIDGE.																				
December to July,	......	.047	.050	.047	.037	......	-6.38	6.00	21.27	......	......	.95	.96	.72	.74	......	-1.05	25.00	-2.78	......
July to December,	.085	.062	.056	.060	.048	27.06	9.68	-7.14	20.00	43.53	1.40	.95	1.05	.76	1.08	32.14	-10.52	27.26	-42.10	22.86
Average for Year,	.103	.053	.052	.053	.042	48.56	1.89	-1.92	20.75	59.23	1.51	.95	1.00	.74	.88	37.09	-5.26	26.00	-18.92	41.72
BLACKSTONE RIVER, SWAMP.																				
December to July,	......	.129	.109	.096	.085	......	15.50	11.93	11.46	......	......	1.21	1.30	.80	.89	......	-7.44	38.46	-11.25	......
July to December,	.377	.178	.139	.150	.127	52.79	21.91	-7.91	15.33	66.31	2.41	1.60	1.24	1.23	1.24	33.61	22.50	.81	-0.81	48.55
Average for Year,	.282	.150	.122	.118	.103	46.81	18.67	3.28	12.71	63.49	2.12	1.36	1.27	.99	1.04	35.85	6.62	22.05	-5.05	50.94
MORSE'S POND.																				
December to July,	......	.108	.093	.097	.082	......	13.89	-4.30	15.46	......	......	1.17	1.15	.94	.92	......	1.71	18.26	2.13	......
July to December,	.211	.157	.157	.141	.119	25.60	00.00	10.19	15.61	43.60	1.37	1.41	1.24	1.06	1.07	-2.92	12.05	14.52	-0.94	21.90
Average for Year,	.175	.129	.120	.115	.098	26.29	6.98	4.17	14.78	44.00	1.43	1.27	1.19	1.00	.98	11.19	6.29	15.97	2.00	31.47
ALDRICH'S POND.																				
December to July,	......	.101	.082	.088	.074	......	18.81	-7.32	15.91	......	......	1.12	.95	.90	.79	......	15.18	5.26	12.22	......
July to December,	.172	.151	.152	.132	.108	12.21	-0.66	13.16	18.18	37.21	1.18	1.27	1.08	.89	.85	-7.63	14.96	17.59	4.49	28.03
Average for Year,	.135	.122	.112	.106	.089	9.63	8.20	5.36	16.03	34.04	1.09	1.18	1.01	.90	.81	-8.26	14.41	10.89	10.00	25.69

TABLE IX.

Condition of Blackstone River below Sewage Precipitation Works. From State Board of Health.

(Parts per 100,000.)

MONTHS.		Residue on Evap'ra'n		Ammonia.					Nitrogen as		
					Albuminoid.						
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
June-November, 1887.....	0.91	....	....	.2686	.1741	....	....	1.35	.0160	....	....
" " 1888.....	0.76	....	....	.3658	.1112	.0557	.0555	1.50	.0882	.0041	....
" " 1889.....	0.86	....	....	.3060	.1430	.0772	.0658	1.32	.0177	.0026	....
" " 1890.....	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891.....	1.05	22.35	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892.....	0.63	26.80	7.75	.5240	.1810	.0858	.0952	3.13	.0137	.0050	10.3
" " 1893.....	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0295	.0126	10.9
" " 1894.....	0.40	29 30	5.86	.6189	.1390	.1113	.0277	2 63	.0212	.0071	10.6
" " 1895.....	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896.....	0.30	24.43	5.73	.2531	.0898	.0600	.0299	2.10	.0217	.0118	9.7
" " 1897.....	0.73	25.68	4.97	.3650	.1122	.0792	.0840	1.61	.0207	.0063	6.9

NOTE.—This table is taken from Mass. State Board of Health Records by permission.

TABLE X.

INCHES OF RAINFALL AT PURIFICATION WORKS, 1896–1897.

Date.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.
1	.20	. .	. .	.08	. .	.	. .	. .	. .	. .	. .	1.05
2	. .	. .	. .	. .	. .	.36	. .	. .	. .	.78	. .	1.55
3	. .	. .	. .	.54	. .	.14	. .	. .	.	. .	. .	. .
4	. .	. .	.	.	. .	. .	.10	. .	. .	. .	. .	. .
5	. .	.50	. .	.40	.12	. .	. .	. .	.65	. .	. .	.
6	. .	. .	. .	. .	.06	. .	. .	. .	. .	. .	. .	. .
7	.10	. .	.95	. .	.21	. .	. .	. .	. .	. .	. .	. .
8	.94	. .	. .	. .	.22	. .	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	1.25	. .	1.25	. .	.28	. .	. .	.70
10	. .	. .	. .	.06	. .	.80	.23	. .	.	. .	. .	. .
11	. .	. .	. .	. .	. .	. .	. .	. .	.10	. .	.30	.40
12	. .	. .	.63	.30	. .	.30	. .	. .	. .	. .	.40	.98
13	. .	. .	. .	. .	. .	.38	.18	1.90	. .	. .	. .	. .
14	. .	. .	. .	.88	. .	. .	.28	.66	. .	. .	. .	. .
15	. .	. .	. .	. .	.18	. .	. .	. .	.18	.	. .	.28
16	.27	. .	.12	. .	. .	. .	. .	. .	.34	. .	. .	. .
17	. .	. .	. .	. .	.32	. .	. .	. .	.03	. .	. .	. .
18	. .	.42	. .	.03	. .	. .	. .	. .	.12	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	.10	. .	.32	. .	. .	.32	.	. .	.10	. .	.13
21	. .	.72	.13	. .	. .	.28	. .	.24	. .	. .	. .	. .
22	. .	. .	. .	. .	. .	. .	. .	1.93	.36	. .	. .	.21
23	.40	. .	.81	. .	. .	. .	. .	.17	. .	.27	. .	. .
24	. .	. .	. .	1.02	. .	. .	. .	.10	.60	.20	. .	. .
25	. .	. .	. .	. .	. .	.72	. .	.14	. .	. .	. .	. .
26	. .	. .	. .	. .	. .	. .	. .	. .	. .	.30	. .	. .
27	. .	.70	. .	. .	. .	. .	. .	. .	. .	. .	. .	.75
28	. .	. .	. .	. .	. .	.03	. .	. .	. .	. .	. .	. .
29	. .	. .	. .	. .	. .	. .	.	.87	. .	. .	. .	. .
30	. .	. .	. .	. .	. .	. .	.82	. .	. .	.	. .	. .
31	. .	. .	. .	. .	. .	.35	. .	. .	. .	. .	. .	. .
Total.	1.91	2.44	2.64	3.63	2.36	3.36	3.18	6.01	2.66	1.65	.70	6.05

FILTER PRESSING PLANT.

Work upon the filter presses was delayed during the first part of the year, as it was deemed wise not to let any contracts for the work until after the report of the experts upon the separating system had been presented. As soon as the report was made public and it was found that no radical change in the methods of sewage treatment was recommended, the contract was let for four filter presses. At the present time one of these machines is erected, and the other three will be installed during the winter. As the plant is not yet completed and running, a detailed description of it is postponed for another year.

MAINTENANCE.

The maintenance of the sewer system is a work which requires constant attention and expenditure, and yet is never thought of or appreciated unless neglected. It is, therefore, not as satisfactory as the other branches of the work of this Department.

Repairs are frequently made to the older portions of the sewer system, and at the present time the sewers, with the exception of the one in Shrewsbury street, are in very good condition. A short portion of the sewer in Shrewsbury street is considerably cracked. It is thoroughly braced by timbers, and is serving its purpose. It should be rebuilt soon, as each year it becomes worse, and is liable to collapse if allowed to remain in its present condition.

By far the largest portion of the work on repairs is caused by the laying of pipes and conduits in the streets and by the making public of private streets and the construction of sidewalks. In such cases many manholes and catch-basins are injured or destroyed. For nearly all of this work bills are rendered to the various city departments and private companies.

As in previous years, such portions of the system as require it are cleaned by scraping and flushing. It is intended to flush all of the smaller pipe sewers at frequent intervals,—the rule being once in six weeks.

The number of catch-basins has increased during the year, and consequently more work is required to keep them in proper condition. During the year, 6,483 loads of refuse have been removed from the basins, at an average cost of $0.60½ per cubic yard. This cost includes money expended for teams as well as for men. The basins are not in as good condition at the close of the present year as usual, because the force employed at cleaning them was withdrawn to assist in the construction of sewers in the separating system, which work has required the service of every available employee of experience in the department. It is believed, however, that no inconvenience will arise from this source.

In closing, the Superintendent desires to express his gratitude to the Committee on Sewers for the interest it has taken in the affairs of the Department and for the aid and support afforded him. It is also pleasant to acknowledge the assistance which has always been willingly furnished by Mr. Matthew Gault and his assistants, who have had charge of the engineering of the Department. Special mention should be made of the efficient and the faithful services rendered by Mr. Julius W. Bugbee, Chemist, and Mr. Robert N. Cundall, Electrical and Mechanical Engineer. To these gentlemen and the several other faithful assistants the credit is due for whatever success has been attained in the work of the year.

Respectfully submitted.

HARRISON P. EDDY,

Superintendent of Sewers.

ANNUAL REPORT

OF THE

SUPERINTENDENT OF SEWERS,

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1898.

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OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1898.

Worcester, Mass.:
PRESS OF F. S. BLANCHARD & CO.,
84 FRONT STREET.
1899.

To the Honorable City Council of the City of Worcester:

In compliance with Section 21, Chapter 34, of the City Ordinances, the following report of the work and condition of the Sewer Department for the fiscal year of 1898 is prepared.

Respectfully submitted,

HARRISON P. EDDY,
Superintendent of Sewers.

Office of the Sewer Department, December 1, 1898.

MEMBERS OF COMMITTEE ON SEWERS, 1898.

President of the Board of Aldermen **Burton W. Potter**, *Chairman.*

Alderman **Napoleon P. Huot.**

Alderman **James H. Mellen.**

President of the Common Council **Frank B. Hall.**

Councilmen **Albert Man Powell.**

Councilman **Frederick W. White.**

Councilman **Bernard H. McMahon.**

REPORT OF THE SUPERINTENDENT OF SEWERS.

A very large amount of work has been done by this department during the past year. Much of it has been difficult, and the excavations have been deep. On account of the depth at which the sewers have been laid and the excessive rainfall, water has been encountered on nearly every piece of work done, and this has greatly added to the difficulties.

As seen from Table I the department has had to its credit a total of $613,223.58, and has expended $368,530.60.

The number of employees has been gradually increased throughout the year, and during the fall over 600 names have been on the weekly pay-rolls. For a number of years previous to 1897 the average working force amounted to about 150 men. Providing tools, stock and machinery, as well as effecting suitable organization and office equipment for the greatly increased work of the last two years, has been no small undertaking.

Sewers have been constructed to the extent of 10.04 miles, and it may be of interest to examine in detail, as follows:

General Construction.

Sewers	3.15
Surface water drains	.58
Total	3.73

Separating System.

Sewers	2.33
Surface water drains	3.76
Total	6.09

Trunk Sewers.

Sewers	2.95
Surface water drains	1.79
Total	4.74

TABLE I.

SUMMARY FOR FINANCIAL RESOURCES FOR 1898.

	Maintenance.	Construction.	Purification.	Statutes of 1897.
Balance Dec. 1, 1897,	$3,637 26	$18,606 60	$22,499 21	$142,725 84
Appropriation,	13,000 00	17,000 00*	55,000 00	†300,000 00
Assessments,	....	20,238 39	....	....
Revenue,	2,787 64	6,817 12	484 81	426 71
Total,	$19,424 90	$62,662 11	$77,984 02	$443,152 55
Total expended,	16,262 72	62,595 34	64,440 83	225,231 71
Balance Dec. 1, 1898,	$3,162 18	$66 77	$13,543 19	$217,920 84

* From license money.
† Loan.

TABLE II.

MATERIALS USED BY THE SEWER DEPARTMENT.

Material.	Contractor.	PRICE PAID.				APROXIMATE AMOUNTS USED.			
		1895.	1896.	1897.	1898.	1895.	1896.	1897.	1898.
Sand,	Amos M. Eaton Estate,	$1.25	$1.00	$0.90	$0.75	454.5 cu. yds.	492.5 cu. yds.	1,819.5 cu. yds.	3,955.5 cu. yds.
Portland Cement,	Frank E. Powers,	......	......	2.15	2.05	....	....	3,260 bbls.*	8,551 bbls.*
Rosendale Cement,	Frank E. Powers,	1.04	0.99	0.86	0.71	1,994 bbls.†	2,978 bbls.†	6,894 bbls.†	3,694 bbls.†
Vitrified Pipe,	Benjamin F. Marsh	......	.....	.....	......	....	....	....	42,305 ft.
Cement Pipe,	James Draper,	......	......	......	......	18,439.7 ft.	19,266.5 ft.	36,565.3 ft.	35,100.5 ft.
Brick,	Frank E. Powers,	6.35	7.25	7.20	7.40	493,000	637,500	2,653,100	2,835,700
Lime,	Frank E. Powers,	5.75	5.50	4.99	4.89	3,243 tons	3,530 tons	3,776 tons	3,507 tons

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* One barrel equals four bags.

† One barrel equals three bags.

TABLE III.

Table of Sewers Constructed During the Financial Year of 1898.

SURFACE SEWERS.

Street.	Location.	Size (inches).	Length (feet).	M. H.
Armory court,	Southgate, southerly,	12	598.3	2
Austin,	Mason to Bellevue,	16 oval	333.9	3
Bancroft,	Chandler, southerly,	12	213.1	2
Beachmont,	Curve from Institute road,	12	37.6	1
Blossom,	Russell to Hudson,	12	633.2	5
Bluff,	Mason to Bellevue,	15	169.7	6
		12	437.6	
Cambridge,	Garfield, westerly,	8.5 x 3	231.5	2
		7.75 x 4	344.8	
Chandler,	Mason to King,	16 x 24	380.4	5
		15	224.5	
Chandler,	Beaver Brook to Mason,	48 round	36.5	9
		45 round	156.3	
		50 x 75	428.3	
		48 x 72	657.4	
Mason,	Chandler to Pleasant,	48 x 72	986.0	
Dewey,	Pleasant, southerly,	12	361.5	4
Dewey,	Parker to Barbour,	15	20.6	3
		12	307.2	
Farnum,	Curve from Institute road,	12	39.2	1
Fremont,	Blackstone river to New York,	18	278.5	6
		15	630.8	
Germain,	Highland, northerly,	12	749.2	5
Highland,	Sever to Schussler road,	15	155.3	3
		12	300.9	
Hope Cemetery,	New York, southerly,	12	252.2	1
Hudson,	Pleasant to Elm,	15	438.9	8
		12	614.3	
Institute road,	Hall to Beachmont,	15	589.9	6
		12	353.7	
King,	Chandler to Jaques avenue.	12	329.8	3
Main,	Maywood to Freeland,	16 x 24	290.8	5
		15	313.9	
Main,	Freeland to Clement,	12	199.6	1
Main,	Webster square to Marble. Relaid for Water Department,	12	466.1	11
		15	426.9	
		18	286.9	
Mason,	Parker to Bluff,	16 x 24	445.4	3
Mason,	Parker to Barbour,	12	335.9	3
Maywood,	Park avenue to Main,	24 x 36	283.9	10
		22 x 33	493.2	
		20 x 30	910.9	
New York,	Fremont to Hope cemetery,	15	21.3	2
		12	268.8	
Oliver,	Park avenue to Woodbine,	12	589.1	5
Park avenue,	Maywood to Shirley,	12	498.7	4
Park avenue,	Beaver brook to Maywood,	24 x 36	790.5	
Parker,	Park avenue to Page.	28	605.4	7
		15	147.8	
Pleasant,	Park avenue to Dewey,	12	212.7	2
Pleasant,	Park avenue, westerly,	18	405.9	5
		16	315.4	
Pleasant,	Mason to Hudson,	18	140.0	2
Pleasant,	Hudson to Dewey,	12	211.6	2
Pleasant,	Mason to Russell,	44 x 66	710.0	4
Richards,	Curve from Main,	12	26.2	1
Russell,	Pleasant to Elm,	36 x 54	820.0	4
Schussler road,	Curve from Highland,	12	21.6	1
Shirley,	Curve from Park avenue,	12	36.3	1
Southbridge, College,	Blackstone river to Caro,	28	235.0	6
		24	150.1	
		20	531.8	
		12	141.3	
Townsend,	Russell to Hudson,	12	669.4	5
Trowbridge road,	Curve from Highland,	12	26.1	1
Winslow,	Pleasant to Austin,	12	675.9	5
Woodland,	Maywood, easterly,	10	183.5	2

Sanitary Sewers.

Street.	Location.	Size (inches).	Length (feet).	M. H.
Armory court,	Southgate, southerly,	15	698.3	2
Burncoat,	Lincoln, northerly, extension,	8	104.7	1
Cambridge,	Sutton lane to Richards,	8	725.1	5
Charlotte,	Florence, easterly,	10	49.5	1
Downing,	Florence, westerly,	8	133.0	2
Elm,	Sever, easterly,	8	1,432.5	11
Englewood avenue,	Isabella to Lisbon,	12	325.9	2
Grove,	North to new street,	18	341.7	3
New,	Grove to Park avenue,	12	663.4	4
Park avenue,	New street to Pratt court,	10	343.4	3
Pratt court,	Park avenue to Whitman road,	8	623.4	4
Whitman road,	Pratt court, northerly,	8	162.8	2
Whitman road,	Pratt court, southerly,	8	218.2	2
Sagamore road,	Park avenue to Monadnock road.	8	1,016.2	6
Monadnock road,	Sagamore road, northerly,	8	281.2	3
Whitman road,	Sagamore road, southerly,	8	729.9	5
Park avenue,	New street to Salisbury,	12	1,498.4	9
Salisbury,	Park avenue, northerly,	10 8	801.4 841.9	11
Monadnock road,	Salisbury to Sagamore road,	8	161.9	1
Harrison avenue,	M. H. No. 2, southerly,	12	125.5	1
Hawthorn,	Main to Woodland,	8	376 8	2
Haviland,	Highland to Institute road,	8	996.1	5
Illinois,	Crystal, easterly, reconstructed,	8	75.4	1
Keese,	Grafton, easterly,	8	307.2	2
Lafayette,	Quinsigamond avenue to Washington	32 x 42	1,582.7	9
Larch,	Winslow to South Russell,	8	210.1	2
Lisbon,	Englewood avenue to Circuit evenue.	8	447.6	4
Main,	Market, northerly, extension,	12	116.3	1
Mill,	Park avenue to Lake,	15	968.1	7
Millbrook,	Outfall sewer to Cambridge,	——	3,660.0	-
Millbury,	Cambridge to Sigel,	48	2,100.0	10
Murray avenue,	Wellington to Dale,	10	681.4	6
North Park way,	Burncoat, easterly,	8	213.5	2
Oswald,	Stebbins, southerly,	8	340.5	3
Pleasant,	Curve at South Russell,	18	15.2	1
Quinsigamond ave.,	Gate chamber to Lafayette.	48	2,440.1	12
Richards,	Curve from Cambridge,	8	21 0	1
Sewer location,	Harlow to Lyford,	10	1,014 7	8
Lyford,	Sewer location to Paine,	8	410.1	4
Gilman,	Sewer location to Paine,	8	409.0	4
Vinton,	Sewer location to Paine,	. 8	418.3	4
South Russell,	Pleasant to Larch,	8	399.0	4
Stebbins,	Thenius to Oswald,	8	193.3	1
Washington,	Lafayette, northerly,	32 x 42	415.0	2

NOTE.—Harrison avenue, North Park way and Keese street were constructed for private parties.

Total sewers and drains	10.04
Total number of man-holes built......	346
Total number of catch-basins built....	46

The additional sewers constructed during the year, with the length, size and location of each, is given in detail in Table I.

A very large amount of work has been required for the execution of this work, and it may be interesting to compare the quantities of the different supplies used this year with those used in past seasons, as well as the prices paid for them, all of which may be found in Table II.

As recommended in the annual report of 1897, it is quite necessary that the city ordinances pertaining to house connections should be modified to conform to the changes necessitated by the adoption of the separating system.

For several years attention has been called to the necessity of securing more suitable buildings and an additional amount of storage space at the East Worcester street headquarters. What was necessary in the past has been made much more so by the great increase in the work put upon this department during the past year, as well as by the continued depreciation of the wooden buildings, which were not of the best quality when built.

While the shop has been made to answer the purposes for which it was designed, the floors have required frequent shoring, and are now in a very unsafe condition. Much work has been done in the open air because of lack of room inside, and this causes delay and additional expense in the work in hand, as well as embarrassment of the work on the sewers caused by such delay.

The shed rented from the adjoining estate, formerly belonging to Darling brothers, is a very poor accommodation for the four horses kept there, and is secured at a high price, as there is no other available shelter which can be used for a stable.

The machinery owned by the department is in very good condition, considering the amount of work it has done. One hoisting engine, which has been used for many years, should be disposed of and a new and modern machine purchased to replace it.

Two new Carson excavators have been built, and have been in constant use since they were completed. The excavator previously owned by the city has been in use during the entire season, and a fourth one has been rented from the Carson Trench Machine Company since September 1.

Several additions to the shop equipment are very necessary, but can not be provided until more room is available.

A pile-driver has been built, but has not been used yet, as at several places where it was at first intended to drive piles other methods were adopted. This machine will, however, prove of much use in future years, as there are many places where it will be required.

The large Rand air-compressor which has been used for nearly fifteen years will be taken from the purification works, where a small one has been ordered to take its place, and erected at the power station to furnish compressed air for the tunnel work in Water street. It is doubtful if it will be able to furnish sufficient air for this work without assistance from another machine, and if it runs until this sewer is completed it can be considered to have served its usefulness, and should be disposed of, as it would be hardly worth repairing for future use.

MAINTENANCE.

This branch of the work has received its usual attention. The repairs required by the system have not been large or expensive. Most such work is caused by laying of street railway lines, gas mains, conduits and water pipes, and is paid for by the parties requiring the work done.

The cleaning of sewers and catch-basins has, as in years past, required constant attention. The amount of this work which has to be done is very largely dependent upon the weather, and upon the cleanliness of the streets. There have been many heavy rains during the year, and on this account it has been necessary to clean the catch-basins frequently. This has not, however, been excessive, because the streets and gutters, especially the latter, have been well cleaned. The advantage and consequent saving in expense of removing refuse from the streets and gutters in dry condition, rather than allowing it to be washed into catch-basins and sewers,

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the entire year. Nearly all of this work has been very heavy, and some of it quite difficult.

The various intercepting sewers, as laid out in the original plan, converge to one point at the junction of Cambridge street and Quinsigamond avenue. From this point the sewage is to be carried inside the Millbrook sewer in a special carrier, which is to connect with the outfall sewer at Quinsigamond Village.

The conduit inside Millbrook, which was begun in 1897, was finished during the early part of 1898. The Mill brook sewer, from Cambridge street to the Blackstone river, is eighteen feet wide and thirteen feet high, and until recently received all the sewage and storm water of the sewer system, as well as the drainage, from a large water-shed in the northern part of the city. Inside of this sewer, and about one-third the distance from the west wall, a partition constructed of brick and Portland cement was built about five feet high, and this narrow section was arched from the partition wall to the side of the large sewer. In this new structure sewage is to flow to the outfall sewer, while the rest of the space in the large sewer will be for storm water, which will be discharged direct into the Blackstone river at Quinsigamond. The new conduit has a capacity of about 50,000,000 gallons per twenty-four hours.

Upon completion of this conduit, work was begun upon the three interceptors which are to empty into it. The one in Millbury street is a round sewer 48 inches in diameter, and will intercept the sewage entering Millbrook from the eastern portion of the city. This sewer will be completed nearly to Vernon street this year.

The west interceptor will be completed nearly to Green street before work is stopped for the winter, and will run through Quinsigamond avenue, Lafayette, Washington and Bradley streets. In Quinsigamond avenue the sewer is 48 inches in diameter, and from there to Green street it has a 32 inch by 48 inch oval section with the large end down.

In Cambridge street the surface water sewer with necessary connections and overflows has been practically completed to its junction with the old sewer at Kansas street. This section required special treatment because of the very limited depth to which the sewer could be placed. On this account a very wide flat conduit with a flat top was substituted for the usual round or oval shape. This conduit was constructed of American Portland cement concrete, and in the roof there was a layer of expanded metal to strengthen the arch. The portion of the sewer which will at times work under considerable head, was covered with I beams at intervals of four feet. These beams were anchored to the concrete invert so that there will be no possibility of the roof of the sewer being lifted by the pressure of the water. From Kansas street through Cambridge, Washburn and Southbridge streets to Hammond street the sanitary sewers which have been ordered can be built during the first part of the coming year.

The work of completely duplicating the sewer system of the west side has been completed as far north as Pleasant street, and the catch-basins have been connected with the surface water sewers, which discharge directly into Beaver brook.

The catch-basins in the South Worcester district, where surface water sewers were built last year, have been connected so that the surface water is now discharged into Stillwater pond. The work done in this district, as well as that completed on the west side, has become of immediate use upon the connection of the catch-basins.

It is very necessary to prosecute the work upon the east and west main carriers as rapidly as possible, so that the work already done may become of use, and also relief may be afforded to the low-lying districts in the southern and eastern sections of the city, which are seriously troubled by back water from the present sewers in time of severe showers and storms. To this end it is intended to push the work in tunnels in Green and Water streets during the coming winter.

PURIFICATION.

There has been no material change in the method of treating the sewage during the past year. The very heavy and frequent rains have rendered the work more difficult than during years of normal rainfall. On this account the results of the treatment have not quite reached the high standard of 1896 and 1897. They have, however, been very good, as will be seen from Table IV, which gives the comparative results of the treatment from year to year. From Table V the comparative results of the treatment from year to year can be studied by seasons. It will be seen that the high water of the latter part of the year had its effect upon the work.

The results of analyses of the sewage and effluent can be studied by months from Table VI.

As in previous years, frequent analyses have been made of the Blackstone river water at various points above and below the discharge of the effluent at the purification works. The results of these analyses are given in Table VII and Table VIII, from which it will be seen that during the year the condition of the river water has improved below the purification works, while it has become more polluted above them. This improvment is most marked at Aldrich's mills, where it reached 28.08 per cent. over last year and 52.6 per cent. over 1893. For the summer months this improvement is even more noticeable, having run as high as 37.04 per cent. over last year and 60.46 per cent. over the corresponding months of the year 1893.

During the year an average of 17.7 million gallons of sewage have been treated daily, and for this treatment 1,073 pounds of lime have been used per million gallons. As a result of the treatment 50,473,177 gallons of sludge have been removed from the settling basins. Something over 20,000 two-horse loads of dry sludge have been hauled on to the adjacent farms.

FILTER PRESSES.

During the year the filter presses have been put in operation, and they are running in a most satisfactory manner. While it is expected that the results of this treatment will materially improve in the near future, it can be said at the present time that the presses have proved more efficient than was expected when the order was placed for their construction. All of the sludge is being pressed, and it has not been found necessary to run the plant all of the time, as was at first estimated. In all probability this work can be done in two 60-hour shifts per week during a greater part of the year. In early fall, when most sludge is produced, it may be necessary to run 24 hours per day for perhaps two months. The breakage of plates and other parts of the presses is not amounting to nearly as much as was anticipated, and if there is no material increase in the future the breakage will be but nominal.

In the early spring the contract was let to Mr. J. Edward Fuller, Jr., to construct a brick building for the filter-pressing machinery. This building was completed so that it could be used in the early fall, and is the most substantial building and the one best adapted for the work to be done in it of any at the purification works.

TABLE IV.

Per Cent. Organic Matter Removed from Sewage.

DESCRIPTION.	1893	1894	1895	1896	1897	1898
Total amount (by evaporation),	50.88	49.35	—	—	—	—
Amount in suspension (by evaporation),	90.67	94.45	—	—	—	—
Total amount (by albuminoid ammonia),	48.49	50.79	51.63	53.92	53.02	51.82
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11	92.02	93.46	92.62
Total amount (by oxygen consumed),	33.65	43.84	54.35	51.62	52.00	48.89
Amount in suspension (by oxygen consumed),	80.85	81.08	78.01	—	—	—

NOTE: Although the determination of oxygen consumed has been made throughout the year, it is not considered as reliable as the determinations of albuminoid ammonia, because of larger amounts of iron present in the sewage, and also because the determination itself is by no means as satisfactory as that for albuminoid ammonia.

TABLE V.

Per Cent. Organic Matter Removed from Sewage by Seasons.

DESCRIPTION.	DECEMBER TO JULY.					JULY TO DECEMBER.					
	1894.	1895.	1896.	1897.	1898.	1893.	1894.	1895.	1896.	1897.	1898.
Total amount (by evaporation),	42.76	—	—	—	—	50.88	55.02	—	—	—	—
Amount in suspension (by evaporation),	93.08	—	—	—	—	90.67	95.76	—	—	—	—
Total amount (by albuminoid ammonia),	46.63	49.69	52.00	48.91	48.67	48.49	53.78	52.93	56.10	57.14	54.86
Amount in suspension (by albuminoid ammonia),	83.26	91.73	91.45	92.19	93.55	76.67	94.36	90.75	93.35	94.30	91.58
Total amount (by oxygen consumed),	37.11	46.92	50.78	48.84	46.20	33.65	50.23	61.08	53.15	55.46	50.84
Am't in suspension (by oxygen consumed),	89.27	82.95	—	—	—	80.85	92.42	72.91	—	—	—

TABLE VI.

Monthly Averages of Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED		Chlorine.
		ALBUMINOID.					
	Free.	Total.	Dis-solved.	Sus-pended.	Un-filtered.	Filtered.	
Sewage, December, 1897	.812	.369	.185	.184	4.76	2.77	4.10
Effluent, " "	.761	.183	.156	.027	2.55	2.55	4.10
Per cent. removed	6.28	50.41	15.68	85.33	46.43	7.94	0.00
Sewage, January, 1898	.692	.327	.159	.168	3.33	1.86	3.92
Effluent, " "	.658	.163	.153	.010	1.99	1.99	3.92
Per cent. removed	4.91	50.16	3.77	94.06	40.24	-6.99	0.00
Sewage, February, 1898	.533	.286	.141	.145	2.75	1.55	3.47
Effluent, " "	.493	.171	.162	.009	1.57	1.57	3.45
Per cent. removed	7.50	40.21	-14.89	93.78	42.91	-1.29	0.58
Sewage, March, 1898	.436	.278	.148	.130	2.71	1.40	3.35
Effluent, " "	.397	.142	.139	.003	1.40	1.40	3.37
Per cent. removed	8.95	48.56	6.08	97.70	48.34	0.00	-0.60
Sewage, April, 1898	.670	.365	.183	.182	3.09	1.65	4.07
Effluent, " "	.624	.197	.190	.007	1.69	1.69	4.09
Per cent. removed	6.87	46.03	-3.89	96.14	45.30	-2.45	-0.49
Sewage, May, 1898	.816	.442	.243	.199	3.62	1.84	4.41
Effluent, " "	.770	.228	.217	.011	1.84	1.84	4.39
Per cent. removed	5.64	48.42	10.70	94.48	49.17	0.00	0.45
Sewage, June, 1898	1.239	.560	.268	.292	3.94	1.79	6.14
Effluent. " "	1.114	.268	.252	.016	1.84	1.84	6.22
Per cent. removed	10.09	52.14	5.97	96.72	53.30	-2.79	-1.33
Sewage, July, 1898	1.616	.734	.382	.352	5.44	3.55	7.63
Effluent, " "	1.416	.318	.285	.033	2.99	2.99	7.89
Per cent. removed	12.38	56.67	25.39	90.63	45.04	15 78	-3.41
Sewage, August, 1898	.876	.489	.232	.257	5.07	2.94	5.68
Effluent, " "	.781	.235	.218	.017	2.65	2.65	5.87
Per cent. removed	10.85	51.94	6.03	93.40	47.73	9.87	-3.35
Sewage, September, 1898	1.068	.543	.267	.276	4.95	2.35	6.10
Effluent, " "	.945	.240	.219	.021	2.03	2.03	6.13
Per cent. removed	11.55	55.80	17.98	92.39	59.00	8.64	-0.49
Sewage, October, 1898	.869	.521	.254	.267	4.60	2.23	5.12
Effluent, " "	.803	.222	.199	.023	2.25	2.25	5.20
Per cent. removed	7.59	57.40	22.05	91.39	51.09	-0.90	-1.56
Sewage, November, 1898	.564	.334	.182	.152	3.94	2.04	3.00
Effluent. " "	.519	.166	.150	.016	1.85	1.85	3.02
Per cent. removed	7.98	50.30	17.68	89.48	50.52	9.31	-0.67
Sewage for year ending Dec. 1, 1898	.851	.438	.221	.217	4.03	2.17	4.76
Effluent " " "	.775	.211	.195	.016	2.06	2.06	4.81
Per cent. removed	8.93	51.82	11.77	92.62	48.89	5.07	-1.05

NOTE: Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half-hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of sampling. Effluent samples consist of twenty-four portions taken hourly.

TABLE VII.

AVERAGES OF WEEKLY ANALYSES OF WATER FROM THE BLACKSTONE RIVER FROM DECEMBER, 1897, TO JULY, 1898; JULY, 1898, TO DECEMBER, 1898, AND FROM DECEMBER, 1897, TO DECEMBER, 1898.

(*Parts per 100,000.*)

WHERE TAKEN.	DATE OF COLLECTION.	Free Ammonia.	Total Albuminoid Ammonia.	NITROGEN AS		Total Oxygen Consumed.	Chlorine.
				Nitrates.	Nitrites.		
Washburn & Moen pond	Dec. 1, 1897, to July 1, 1898	.013	.024	.007	.0001	0.48	0.45
" " "	July 1, 1898, to Dec. 1, 1898	.017	.039	.034	.0009	0.77	0.56
" " "	Dec. 1, 1897, to Dec. 1, 1898	.015	.030	.017	.0004	0.60	0.49
Bridge	Dec. 1, 1897, to July 1, 1898	.070	.047	.018	.0012	0.88	1.19
"	July 1, 1898, to Dec. 1, 1898	.114	.071	.040	.0024	1.09	1.45
"	Dec. 1, 1897, to Dec. 1, 1898	.088	.057	.027	.0017	0.96	1.29
Swamp	Dec. 1, 1897, to July 1, 1898	.192	.115	.022	.0037	1.02	1.66
"	July 1, 1898, to Dec. 1, 1898	.324	.105	.043	.0086	1.16	2.20
"	Dec. 1, 1897, to Dec. 1, 1898	.245	.111	.031	.0057	1.08	1.88
Morse pond	Dec. 1, 1897, to July 1, 1898	.208	.067	.023	.0026	0.65	1.69
" "	July 1, 1898, to Dec. 1, 1898	.361	.121	.041	.0041	1.12	2.45
" "	Dec. 1, 1897, to Dec. 1, 1898	.270	.089	.030	.0032	0.84	2.00
Aldrich pond	Dec. 1, 1897, to July 1, 1898	.179	.061	.022	.0018	0.87	1.38
" "	July 1, 1898, to Dec. 1, 1898	.349	.068	.033	.0043	0.86	2.34
" "	Dec. 1, 1897, to Dec. 1, 1898	.248	.064	.026	.0028	0.87	1.77

TABLE VIII.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1898 INCLUSIVE.

	TOTAL ALBUMINOID AMMONIA. [Parts per 100,000.]						PER CENT. IMPROVEMENT.					
	1893	1894	1895	1896	1897	1898	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98	'93-'98
WASHBURN & MOEN'S POND.												
December to July	......	.023	.032	.025	.022	.024	......	-39.13	21.25	12.00	-9.09	......
July to December	.052	.054	.050	.042	.037	.039	-3.84	7.41	16.00	11.91	-5.41	25.00
Average for year	.047	.037	.039	.032	.028	.030	21.28	-5.41	17.95	12.50	-7.14	36.16
BLACKSTONE RIVER, BRIDGE.												
December to July	......	.047	.050	.047	.037	.047	......	-6.38	6.00	21.27	-27.04	......
July to December	.085	.062	.056	.060	.048	.071	27.06	9.68	-7.14	20.00	-47.92	16.47
Average for year	.103	.053	.052	.053	.042	.057	48.56	1.89	-1.92	20.75	-35.72	44.67
BLACKSTONE RIVER, SWAMP.												
December to July	......	.129	.109	.096	.085	.115	......	15.50	11.93	11.46	-26.08	......
July to December	.377	.178	.139	.150	.127	.105	52.79	21.91	-7.91	15.33	20.95	72.16
Average for year	.282	.150	.122	.118	.103	.111	46.81	18.67	3.28	12.71	-7.21	60.64
MORSE'S POND.												
December to July	......	.108	.093	.097	.082	.067	......	13.89	-4.30	15.46	18.29	......
July to December	.211	.157	.157	.141	.119	.121	25.60	00.00	10.19	15.61	-1.68	42.65
Average for year	.175	.129	.120	.115	.098	.089	26.29	6.98	4.17	14.78	9.18	49.15
ALDRICH'S POND.												
December to July	......	.101	.082	.088	.074	.061	......	18.81	-7.32	15.91	17.57	......
July to December	.172	.151	.132	.152	.108	.168	12.21	-0.66	13.16	18.18	37.04	60.46
Average for year	.135	.122	.112	.106	.089	.064	9.63	8.20	5.36	16.03	28.08	52.60

TABLE VIII.—*Continued.*

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1898 INCLUSIVE.

	TOTAL OXYGEN CONSUMED. [Parts per 100,000.]						PER CENT. REMOVED.					
	1893	1894	1895	1896	1897	1898	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98	'93-'98
WASHBURN & MOEN'S POND.												
December to July	......	.74	.75	.64	.59	.48	......	1.35	12.33	7.81	18.64	......
July to December	1.21	.87	1.14	.64	.67	.77	28.10	-31.03	43.86	-4.69	-14.92	36.07
Average for year	1.03	.79	.90	.64	.62	.60	23.30	-13.93	28.89	3.11	3.22	41.76
BLACKSTONE RIVER, BRIDGE.												
December to July	......	.95	.96	.72	.74	.88	......	-1.05	25.00	-2.78	-18.92	......
July to December	1.40	.95	1.05	.76	1.08	1.09	32.14	-10.52	27.26	-42.10	-0.92	22.15
Average for year	1.51	.95	1.00	.74	.88	.96	37.09	-5.26	26.00	-18.92	-9.09	36.42
BLACKSTONE RIVER, SWAMP.												
December to July	......	1.21	1.30	.80	.89	1.02	......	-7.44	38.46	-11.25	-14.61	......
July to December	2.41	1.60	1.24	1.23	1.24	1.16	33.61	22.50	0.81	-0.81	6.45	51.87
Average for year	2.12	1.36	1.27	.99	1.04	1.08	35.85	6.62	22.05	-5.05	-3.85	49.06
MORSE'S POND.												
December to July	.....	1.17	1.15	.94	.92	.65	......	1.71	18.26	2.13	29.35	.....
July to December	1.37	1.41	1.24	1.06	1.07	1.12	-2.92	12.05	14.52	-0.94	-4.57	18.25
Average for year	1.43	1.27	1.19	1.00	.98	.84	11.19	6.29	15.97	2.00	14.29	41.27
ALDRICH'S POND.												
December to July	.....	1.12	.95	.90	.79	.87	.....	15.18	5.26	12.22	-10.13	......
July to December	1.18	1.27	1.08	.89	.85	.86	-7.63	14.96	17.59	4.49	-1.18	27.11
Average for year	1.09	1.18	1.01	.90	.81	.87	-8.26	14.41	10.89	10.00	-7.41	20.18

ANNUAL REPORT

OF THE 9

SUPERINTENDENT OF SEWERS,

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1899.

TOGETHER WITH A RESUME OF THE STUDIES
AND PROGRESS MADE TOWARD THE
SOLUTION OF THE

SEWERAGE PROBLEM.

Worcester, Mass.:
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34 FRONT STREET.
1900.

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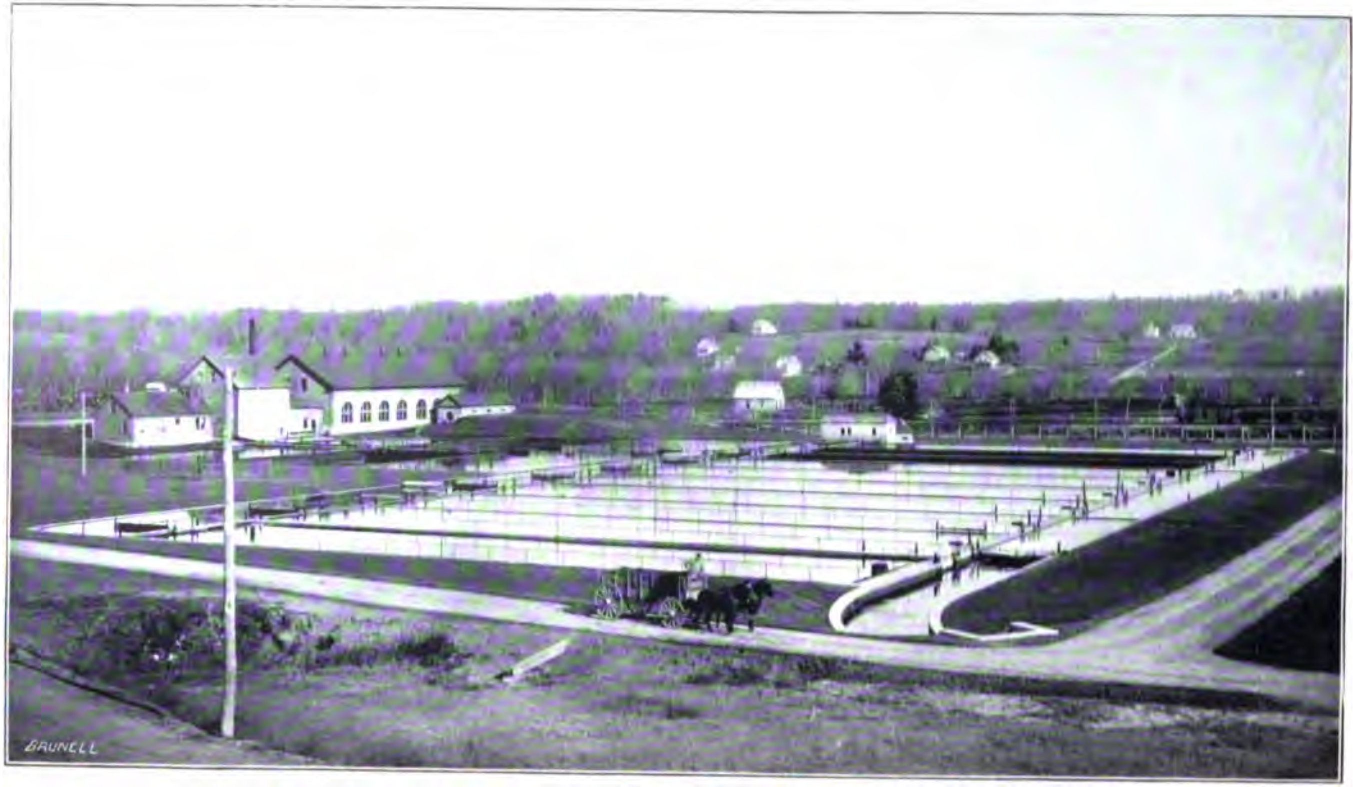

CUT A.

PRECIPITATION PLANT.

ANNUAL REPORT

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To the Honorable City Council of the City of Worcester:

In compliance with Section 21, Chapter 34, of the City Ordinances, the following report of the work and condition of the Sewer Department for the fiscal year of 1899 is prepared.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

Office of the Sewer Department, December 15, 1899.

MEMBERS OF THE COMMITTEE ON SEWERS, 1899.

[illegible] Alderman Henry Branson, Chairman.

[illegible]

Alderman James F. [illegible]

[illegible] Councilman Frederick W. White.

[illegible]

Councilman [illegible] Lundberg.

Councilman Bernard H. McMahon.

REPORT OF THE SUPERINTENDENT OF SEWERS.

During the fiscal year of 1899 this department has done the largest amount of work accomplished in any year since its organization. The winter of 1898 and 1899 was occupied with tunnel work in Green and Water streets. About 250 men were employed in this way. Throughout the remainder of the year about 550 men have been on the department rolls. Many of the constructions have been very difficult, and most of the trenches have been heavy. Not as large quantities of water have been encountered as during 1898, which possibly has been due to the drought which lasted throughout the entire year.

As seen from Table II the department has been credited with $604,191.30, of which $538,013.32 have been expended.

When it is considered that all work is done by day labor and none by contract, it will be understood that the past year has been a very busy one.

Over twelve miles of sewers have been built, and may be grouped under the following heads: General Construction, Separating System, and Trunk Sewers (both systems), each being subdivided into sewers and surface-water drains.

General Construction.

Sewers	5.34	miles.
Surface water drains	1.56	"
Total	6.90	"

SEPARATING SYSTEM.

Sewers	4.23	"
Surface water drains	1.26	"
Total	5.49	"

TRUNK SEWERS.

Sewers	4.75	"
Surface water drains	.76	"
Total	5.51	"
Total extent of sewers	12.39	"
Total number of manholes built	426	
Total number of catch-basins built	166	

No very material additions have been made to the machine equipment. Several new steam-drills were purchased of the Rand Drill Co. of New York for the tunnel work, and they have been used somewhat on open cut work, especially in Pleasant street. A few machines have been bought for the shop, but they have not yet been set up for use. All of the excavators have been in use throughout the year, and two have been hired for use from the Carson Trench Machine Co. of Boston. All the engines and boilers owned have been almost constantly in use, and one hoisting-engine has been borrowed from the Water Department and another hired from a contractor.

The pile-driver was set up in the fall and will run until stopped on account of cold weather. There will be considerable work for it during the next year, if the work progresses.

The leasing of the property formerly occupied by Darling Brothers has been of great assistance in providing much needed storage space. The city has the option to buy this property, and the purchase should be made as soon as possible. The shop has been badly crowded during the busy season, much work having been done in adjacent buildings and in the open air at great disadvantage.

The work done at the shop, including the light trucking done by the delivery teams owned by the department, has amounted to $38,638.30.

TABLE I.

MATERIALS USED BY THE SEWER DEPARTMENT.

Material.	Contractor.	Price Paid.				Approximate Amounts Used.			
		1896.	1897.	1898.	1899.	1896.	1897.	1898.	1899.
Sand,	Thomas J. Smith,	$1.00	$0.90	$0.75	$0.875	492.5 cu. yds.	1,819.5 cu. yds.	3,955.5 cu. yds	4,450.9 cu. yds.
Portland Cement,	Smith-Green Co.,	.....	2.15	2.05	1.98	....	3,260 bbls.*	8,551 bbls.*	13,885 bbls.*
Rosendale Cement,	Smith-Green Co.,	0.99	0.86	0.71	0.84	2,978 bbls.†	6,894 bbls.†	3,694 bbls.†	2,770 bbls.†
Vitrified Pipe,	Portland Stoneware Co.,	.....	.....	.....	.....	....	....	42,305 ft.	94,077 ft.
Cement Pipe,	James Draper,	.....	....	.....	.....	19,266.5 ft.	36,565.3 ft.	35,100.5 ft.	39,059 ft.
Brick,	Spiers, Fish & Co.,	7.25	7.20	7.40	8.60	637,500	2,653,100	2,835,700	2,334,093
Lime,	Smith-Green Co.,	5.50	4.99	4.89	4.92	3,530 tons	3,776 tons	3,507 tons	3,844.6 tons

* One barrel equals four bags.

† One barrel equals four paper bags.

Mr. John E. Taylor has had charge of the purchase and distribution of all supplies, and Mr. Harry L. Abbott has had charge of the work done in the shop, together with the accounts, and has also acted as assistant to Mr. Taylor. Much credit is due both for the satisfactory service rendered by the supply department. From Table I some idea can be formed of the amount of stock which has been required for the work accomplished.

TABLE II.

SUMMARY OF FINANCIAL RESOURCES FOR 1899.

	Maintenance.	Construction.	Purification.	Statutes of 1897.
Balance Dec. 1, 1898,	$3,162 18	$66 77	$13,543 19	$217,948 95
Appropriation,	15,500 00	56,600 00*	70,000 00†	170,000 00
Assessments,	....	20,042 31	....	....
Revenue,	2,139 67	32,067 90	1,165 42	1,954 91
Total,	$20,801 85	$108,776 98	$84,708 61	$389,903 86
Total expended,	18,373 67	108,763 90	84,694 98	326,179 77
Balance Dec. 1, 1899,	$2,428 18	$13 08	$13 63	$63,724 09

* $20,000 of this amount from license money.
† $30,000 of this amount from license money.

All cement has been received in bags. The Portland cement was received in cloth sacks, and the Rosendale cement in paper bags. The cement has been taken direct from the cars and hauled by the department. This method has proved very satisfactory, as deliveries have been under complete control, and as large a stock could be kept on hand as was deemed necessary to prevent shortage in case of failure of cars to arrive on time, or of failure of shippers to fill orders. It should be said in this connection, however, that there has not been the slightest delay in the receipt of cement or lime shipments, both of which contracts have been held by the Smith-Green Co. of this

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Vitrified Pipe,	Portland Stoneware Co.,	......	......	......	....	....	....	42,305 ft.	94,077 ft.
Cement Pipe,	James Draper,	......	...	......	....	19,266.5 ft.	36,565.3 ft.	35,100.5 ft.	39,059 ft.
Brick,	Spiers, Fish & Co.,	7.25	7.20	7.40	8.60	637,500	2,653,100	2,835,700	2,334,093
Lime,	Smith-Green Co.,	5.50	4.99	4.89	4.92	3,530 tons	3,776 tons	3,507 tons	3,844.6 tons

* One barrel equals four bags.

† One barrel equals four paper bags.

briquettes have been made, and as many of them as have become due have been broken. These briquettes have been made up neat and with various amounts of standard and common sand.

Aside from special lines of investigation, the samples are tested for periods of time ranging from 24 hours to 3 years. All samples are sifted to ascertain the degree of fineness to which the cement has been ground. Hot-water tests are applied to each sample as soon as it comes to the laboratory to furnish quickly any indication of poor quality. The 24-hour neat test is, however, the one upon which the order is issued to unload or reject a car. The contract does not recognize this test, everything depending upon the seven-day test. As it is very inconvenient, as well as expensive, to keep the cars standing upon the track a full week before unloading, a ratio of the 24-hour test to the week tests is determined and decision is based on the former test, and generally no difficulty is experienced. In all cases if the day test is below the proper standard the week test is correspondingly low.

The general practice has been to make up sets of five briquettes for each test of every sample, and the average of the three showing the highest tests is taken as a fair representation of the cement at the various periods.

Tests are made up from every sample for the 24-hour and seven-day periods, and in perhaps 50 per cent. of the whole number for the longer intervals up to three years.

In the process of making briquettes, the cement is mixed with water to form a mass of pasty consistency, which when packed into the moulds with a wooden tamper becomes quite moist on the surface from the pressing out of the slight excess of water.

Twenty-four hour tests are immersed in water after hard set, while those for longer periods are first kept for one day in the moist closet.

In addition to the mechanical tests, complete chemical analyses have been made of many samples of the cement. These analyses are especially valuable in finding the underburned or diluted cements, which, as in the case of the samples of Victor cement, may give a fairly good 24-hour test.

TABLE III.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT.

June 1, 1898, to December 1, 1898.

BRAND.	No. of Samples Tested.	*FINENESS.			TENSILE STRENGTH.							Spec. Grav.	CHEMICAL ANALYSIS.							
		Per cent. Passing No. 50 Sieve.	Per cent. Passing No. 100 Sieve.	Per cent. Passing No. 200 Sieve.	24 h.	7 d.	28 d.	3 m.	6 m.	9 m.	12 m.		CaO	SiO_2	Fe_2O_3	Al_2O_3	MgO	SO_3	Loss.	Insol.
Atlas,	49	......	.....	......	412	640	715	803	826	836	844	3.171	60.46	22.18	2.74	7.28	3.34	1.53	2.05	0.39
Saylor's,	5	......	.....	......	371	621	658	723	754	834	878	3.210	61.50	22.93	2.06	5.13	5.22	1.95	0.72	0.49
Alsen,	3	.....	....	......	226	366	464	614	568	667	618	3.183	63.31	20.99	3.23	6.94	1.73	2.09	1.15	0.33
Dyckerhoff,	2	.....	....	......	187	349	403	452	673	700	727	3.186	62.81	20.65	3.52	7.46	2.20	1.40	1.05	0.17
Germania,	1	......	.....	......	359	439	555	703	672	669	707	3.176	64.55	22.26	2.64	6.40	1.16	1.80	1.10	0.28
Alpha,	3	......	.....	.....	220	553	695	718	760	697	768	3.217	63.27	21.56	3.12	7.21	2.85	1.17	0.42	0.30
Lehigh,	1	.....	......	....	343	700	858	871	845	841	811	3.209	62.54	21.58	2.52	5.88	2.89	1.61	0.71	0.32
Iron Clad,	1	.....	.....	......	....	333	425	491	654	598	647	3.193	60.86	21.46	6.47	4.75	1.77	1.97	1.48	0.49
Victor,	2	.....	.....	.....	288	480	677	557	709	609	655	3.022	57.92	13.77	2.67	5.26	1.94	1.54	17.96	0.38
Egypt,	2	......	......	......	.....	284	283	350	515	519	574	3.170	58.01	20.50	3.21	7.53	2.90	1.81	6.08	0.24
Hecla,	1	......	.....	......	31	209	276	437	420	511	515	2.933	38.73	12.42	1.58	2.22	12.45	0.83	28.42	3.16

* Note : Fineness tests made in 1898 are omitted from the table because they are not comparable with the results from method in use since.

TABLE IV.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT.

December 1, 1898, to December 1, 1899.

BRAND.	No. of Samples Tested.	FINENESS.			TENSILE STRENGTH.							Spec. Grav.	CHEMICAL ANALYSIS.							
		Per cent. Passing No. 50 Sieve.	Per cent. Passing No. 100 Sieve.	Per cent. Passing No. 200 Sieve.	24 h.	7 d.	28 d.	3 m.	6 m.	9 m.	12 m.		CaO	SiO₂	Fe₂O₃	Al₂O₃	MgO	SO₃	Loss.	Insol.
Alpha,	3	....	....	....	....	370	526	580	590	....	....	3.254	63.08	21.01	2.82	7.52	3.09	1.01	0 36	0.28
Alsen,	3	....	....	....	168	595	500	587	694	630	....	3.183	61 77	20.86	3.23	6.92	1.43	2.25	1.22	0.47
Atlas,	30	99.9	94 0	73.1	339	667	789	780	837	820	....	3.178	59.95	21.59	2.60	6.87	3.77	1.39	1.86	0.44
Dyckerhoff,	1	....	....	....	175	467	579	560	663	....	....	3.188	63.12	20.21	2.99	6.89	1.75	1.29	1.16	0.32
Germania,	1	99.9	93.3	63.8	308	452	531	620	....	....	....	3.192	61.63	21.50	2.71	6.21	1.46	2.33	1.31	0.78
Iron Clad,	5	....	....	....	305	460	499	590	629	652	....	3.211	62.85	21.51	2.93	7.09	2.16	1.56	0.84	0.41
Lehigh,	70	99.7	92 7	71.2	178	568	643	667	723	828	....	3.246	61.26	23.18	2.60	6.05	3.10	1.40	0.76	0.47
Nazareth,	1	100.0	99.4	77.4	190	462	477	627	....	....	....	3.173	57.74	20.83	2.34	6.70	3.49	1.07	3.82	0.99
Saylor's,	8	....	....	....	219	613	709	749	821	890	....	3.209	60.58	23.36	1.90	4.86	4 96	2.00	0.52	0.54
Standard,	1	98.8	90.0	71.2	142	307	423	....	....	....	....	3.030	50.90	24.05	2.89	6.03	3.01	2.45	5.70	2.32
Star,	1	99.9	93.5	....	299	736	....	745	823	....	....	3.204	61.92	22.03	2.63	6.69	3.37	1.64	0.89	0.66
Steel,	1	100.0	98.0	....	159	374	511	....	....	....	....	2.870	51.72	28.64	0.85	11.55	3.87	0.38	3.32	0.44
Victor,	3	....	....	....	325	494	592	635	688	714	....	3.040	58.84	14.09	2.16	4.52	1.73	0.98	15.65	1.07

TABLE V.

RECORD OF TESTS ON ROSENDALE CEMENT—NEAT.

June 1, 1898, to December 1, 1898.

BRAND.	No. of Samples Tested.	*FINENESS.			TENSILE STRENGTH.							Spec. Grav.	CHEMICAL ANALYSIS.							
		Per cent. Passing No. 50 Sieve.	Per cent. Passing No. 100 Sieve.	Per cent. Passing No. 200 Sieve.	24 h.	7 d.	28 d.	3 m.	6 m.	9 m.	12 m.		CaO	SiO_2	Fe_2O_3	Al_2O_3	MgO	SO_3	Loss.	Insol.
Hoffman,	6	.....	.....	......	106	161	255	348	384	387	406	3.197	34.23	24.30	5.22	6.04	21.22	1.88	4 35	1.33
Norton,	3	.....	......	.....	94	127	269	342	366	379	368	3.165	33 95	24.58	2.24	5 74	21.34	1.72	5.18	0.91
New York,	1	......	.....	......	54	111	225	443	330	353	344	3.070	34.19	26.11	5.74	8 61	16.36	1.83	7.19	0.47
December 1, 1898 to December 1, 1899.																				
Hoffman,	8	97.8	90.7	.....	107	154	226	343	397	405	....	3.208	34.72	24.84	4.85	7.02	20.25	1.95	4.80	0.72
Norton,	13	95.8	87.1	60.5	74	118	174	238	.....	.....	.....	3.174	34 78	24.23	4.48	6.27	21.97	2.24	5.54	0.69
New York,	3	......	......	......	73	96	184	365	451	467	.....	3.127	33.06	26.86	3.90	10.34	16.45	1.86	5.90	0.77

* Note: Fineness tests made in 1898 are omitted from the table because they are not comparable with the results from method in use since.

Besides the examination of cements, the inspection of brick, pipe and coal is also included in the work of this division. The testing of oil will also be included during the coming year.

Studies on various questions arising in the work of the department are made from time to time.

All accidents are reported to the chemist in charge of this branch of the work, and are at once investigated, and any photographs of interest taken.

In July, 1895, a Ferguson automatic recording rain-gauge was placed at the purification works. This record has proved a valuable supplement to the gauges of the Water Department, one situated at Leicester and the other at Holden. As all the local records are tabulated in terms of total rainfall per day, it has seemed desirable to increase this information by a more detailed tabulation of the records of the automatic gauge. This gauge almost invariably shows a smaller annual precipitation than is reported from the other gauges mentioned. This is due to the fact that many showers pass over the northern and western watershed which do not reach the centre of the city, and even fewer of them reach the purification works. Table VI gives the usual information, and Tables VII to XI inclusive are calculated from the graphic records. In each table the second column gives the duration of the storms, not infrequently lasting more than 24 hours. From a study of the various columns of these tables it will be learned of what little value a record of total precipitation is in forming an idea of the intensity of the rainfall. Even the figures given in the fourth column furnish little information upon which to base an estimate of the maximum precipitation to be prepared for. In order to furnish this desirable information a careful study has been made of the individual record sheets to determine the maximum intensity of precipitation to be expected, based upon the storms occurring between July 15, 1895, and Dec. 1, 1899. The standard period of time adopted (20 minutes) is, of course, wholly arbitrary. The reason for its adoption was that the scales to which the records were plotted were so small that much shorter periods would depend so largely upon the judgment of the party reading the record that they would not be entirely reliable, and that with showers of less than twenty minutes duration the time required to reach the sewers and to surcharge them would be out of proportion to the length of precipitation, so that such a record would throw very little additional light upon the subject.

This reason is of course open to argument, but it would seem that the twenty-minute period was the most practicable one for use. The results of this study are given in the fifth column of each table. It is interesting to note that usually there are several storms annually in which there is a maximum intensity of from one inch to one and one-half inches per hour for at least one twenty-minute period; that there are a few periods in which the intensity runs between one and one-half inches and two inches, and that there were two periods in the four and one-half years when an intensity of 2.25 inches was reached.

In addition to the periods of maximum precipitation a further selection has been made of the duration of periods of greatest precipitation and the intensity of rainfall during these periods. The results of these studies appear in columns six and seven. It will be noticed that, except in cases of very short showers, the intensity throughout these periods is very much reduced, and that it rarely exceeds one inch, and that when one-half inch is exceeded it is during a shower of less than one hour total duration, with three exceptions, namely, August 31, 1895, November 14-15, 1895, and June 15, 1899.

In addition to the various tests and studies made for this department, numerous analyses have been made for other departments. Most noteworthy among these are the analyses of samples of water frequently undertaken at the instance of the Water Department.

It has been the policy since the beginning of the more difficult and complicated constructions, necessitated by the building of the separating system, to keep a photographic record of the most noteworthy features of the work. A few of these views are presented with this report.

All of the work accomplished in the testing division has been under the direction of the chemist, Mr. Edward L. Smith, to whom especial credit is due for the large amount of valuable information furnished by his department.

TABLE VI.

INCHES OF RAINFALL AT PURIFICATION WORKS, 1898 1899.

Date.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.
1	...	0.25	...	...	...	0.40	...	...	...	0.14	...	0.43
2	...	...	...	0.43	...	...	...	...	...	0.73	...	...
3	...	...	0.27	...	...	...	...	...	...	0.51	...	0.42
4	1.08	...	0.29	0.15	...	...	...	...	...	...	...	0.27
5	...	...	0.12	0.72	...	...	...	...	...	...	...	...
6	...	1.00	...	...	...	...	...	...	...	...	0.33	...
7	...	...	0.18	0.39	0.20	...	...	...	...	...	...	...
8	...	...	0.34	...	0.64	...	...	1.68	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	0.20	...
10	...	...	...	...	...	...	...	...	0.80	...	...	...
11	...	...	...	...	...	0.24	...	...	...	...	...	0.95
12	0.27	...	0.25	0.19	0.13	...	...	0.08	...	...	...	0.13
13	...	...	1.48	...	...	...	...	...	...	...	...	...
14	...	0.40	...	...	...	...	0.15	...	...	...	...	...
15	...	...	...	0.90	...	...	1.95	...	...	...	...	0.16
16	...	0.33	0.07	...	0.87	0.16	...	0.15	...	...	...	...
17	...	0.57	0.23	...	0.03	...	...	...	...	...	...	...
18	...	...	0.25	0.45	...	...	...	...	...	...	0.38	...
19	...	...	...	0.87	...	...	0.10	...	...	...	...	...
20	0.50	...	...	...	...	...	0.30	...	...	1.93	0.11	...
21	...	...	...	...	0.19	...	...	...	...	0.67	...	...
22	0.34	...	...	...	...	...	...	...	0.82	...	...	...
23	0.21	...	...	0.53	...	...	...	...	...	...	...	...
24	...	0.87	...	...	...	...	0.23	...	...	...	...	...
25	...	0.31	...	...	...	...	0.08	0.15	...	...	...	...
26	...	...	0.10	0.32	...	...	...	0.66	...	0.20	...	...
27	...	...	0.17	...	...	...	...	0.40	...	...	...	...
28	...	...	...	0.32	...	0.10	0.56	...	...	...	...	...
29	...	...	...	...	...	...	0.43	...	...	...	0.30	...
30	...	...	...	...	...	...	...	0.15	...	0.12	...	...
31	0.55	...	...	...	...	...	...	...	...	...	0.60	...
	2.95	3.73	3.75	5.27	2.06	0.90	3.80	3.27	1.62	4.30	1.92	2.36

Grand Total, 35.91.

TABLE VII.

RAINFALL AT THE PURIFICATION WORKS DURING THE FISCAL YEAR OF 1895.

DATE.	DURATION OF STORM.	Total Precipitation in Inches.	Rate per Hour in Inches.	Rate per Hour for 20-Minutes of Maximum Precipitation in Inches.	PERIOD OF GREATEST PRECIPITATION.	Rate per Hour in Inches.
July 15,	5.3 hours from 10.00 A. M.	.13	.025	.12	.7 hours from 10.00 A. M.	.11
July 21,	0.3 " " 3.40 P. M.	.30	.900	.90		
July 21-22	5.3 " " 8.00 P. M. of 21st.	.27	.051	.39	1.3 " " 11.40 P. M. of 21st.	.18
July 27,	6.0 " " 6.00 P. M.	.15	.025	.15	2.3 " " 6.20 P. M.	.05
Aug. 7,	4.7 " " 9.20 A. M.	1.30	.277	1.95	.7 " " 11.00 A. M.	1.50
Aug. 12,	3.3 " " 4.00 A. M.	.12	.036	.18	.7 " " 4.00 A. M.	.10
Aug. 18,	4.7 " " 7.00 A. M.	1.78	.379	.48		
Aug. 28,	1.0 " " 9.20 P. M.	.55	.550	1.35	.7 " " 9.20 P. M.	.71
Aug. 31,	4.7 " " 3.40 P. M.	1.25	.266	1.20	1.0 " " 6.40 P. M.	.98
Sept. 9-10	6.7 " " 9.20 P. M. of 9th.	.56	.083	.51	1.7 " " 9.20 P. M. of 9th.	.18
Sept. 11,		.32				
Sept. 18,	4.3 " " 7.40 A. M.	.20	.047	.15	2.0 " " 7.40 A. M.	.06
Sept. 26,	2.0 " " 4.00 A. M.	.13	.065	.24	1.0 " " 4.00 A. M.	.10
Sept. 26,	5.0 " " 6.00 P. M.	.12	.024	.23	.7 " " 7.20 P. M.	.11
Sept. 30,	5.0 " " 12.40 A. M.	.62	.124	1.05	1.3 " " 12.40 A. M.	.38
Oct. 12-14	34.0 " " 3.00 P. M. of 12th.	7.72	.227	.96		
Oct. 31,		1.85				
Nov. 2,	11.3 " " 11.40 A. M.	.46	.041	.12	6.3 " " 11.40 A. M.	.06
Nov. 10,	2.3 " " 3.40 A. M.	.10	.043	.11	1.0 " " 3.40 A. M.	.08
Nov. 14-15	21.0 " " 7.00 P. M. of 14th	2.70	.129	1.32	4.0 " " 2.00 A. M. of 15th.	.52
Nov. 17,	9.3 " " 12.00 M.	1.21	.130	.38	4.3 " " 1.20 P. M.	.20
Nov. 20,	5.3 " " 2.20 P. M.	.25	.047	.23	1.7 " " 4.00 P. M.	.08
Nov. 24,	8.7 " " 12.00 P. M. of 23rd.	.25	.029	.09	5.3 " " 12.00 P. M. of 23rd.	.04
Nov. 25-26	35.0 " " 12.20 P. M. of 25th.	1.42	.041	.69	8.3 " " 2.20 P. M. of 25th.	.15

[illegible]	[illegible]	[illegible] P.M.	[illegible] 23d	[illegible]
[illegible]	[illegible]	[illegible] P.M.		[illegible]
[illegible]	[illegible]	[illegible] P.M.	[illegible] 21st	[illegible]
[illegible]	[illegible]	[illegible] A.M.		[illegible]
[illegible]	[illegible]	[illegible] P.M.		[illegible]

TABLE IX.

RAINFALL AT THE PURIFICATION WORKS DURING THE FISCAL YEAR OF 1897.

DATE.	DURATION OF STORM.		Total Precipitation in Inches.	Rate per Hour in Inches.	Rate per Hour for 20 Minutes of Maximum Precipitation in Inches.	PERIOD OF GREATEST PRECIPITATION.		Rate per Hour in Inches.
	Hours.	From				Hours.	From	
Dec. 1	5.0	7.00 P.M.	.20	.040	.11			
Dec. 8	12.3	12.00 P.M. of 7th.	1.04	.084	.26	8.0	12.00 P.M. of 7th.	.05
Dec. 15	10.0	7.00 A.M.	*.27	.027				
Dec. 23			*.40					
Jan. 5			.50					
Jan. 17-18	8.0	10.20 P.M. of 17th.	.42	.052	.15	5.3	11.00 P.M. of 17th.	.06
Jan. 22-21	17.0	8.00 P.M. of 20th.	†.82	.048	.21	7.0	3.20 A.M. of 21st.	.10
Jan. 27-28			*.70					
Feb. 7	10.0	11.20 P.M. of 6th.	.93	.093	.30	7.0	1.00 A.M.	.13
Feb. 12	14.7	9.20 A.M.	*.63	.043	.13			
Feb. 15-16	13.0	11.00 P.M. of 15th.	*.12	.092				
Feb. 20-21	5.5	10.30 P.M. of 20th.	*.13	.024				
Feb. 22-23	10.7	10.40 P.M. of 22nd.	†.81	.076	.24	5.7	10.40 P.M. of 22nd.	.11
Mar. 1			*.08					
Mar. 2-3	22.3	7.40 P.M. of 2nd.	.54	.024	.30			
Mar. 5	8.0	12.40 P.M.	.40	.050	.21			
Mar. 10			.06					
Mar. 12	3.0	1.20 P.M.	.30	.100	.27	1.7	1.40 P.M.	.16
Mar. 14	8.0	9.40 A.M.	*.38	.047	.18			
Mar. 18			.03					
Mar. 20	14.3	1.40 A.M.	.82	.058	.18	6.7	1.40 A.M.	.10
Mar. 24	16.3	12.00 P.M. of 23rd.	1.02	.063	.42	5.0	1.20 A.M.	.11
Apr. 5	3.7	1.20 A.M.	.12	.032	.13	1.0	2.00 A.M.	.08
Apr. 6			.06					
Apr. 7 8	14.0	3.20 P.M. of 7th.	.31	.022	.18	4.7	5.20 P.M. of 7th.	.04
Apr. 8-9	25.7	9.20 P.M. of 8th.	1.37	.053	.45	21.0	10.00 P.M. of 8th.	.06
Apr. 15	12.3	4.20 A.M.	.18	.014	.05	5.0	5.00 A.M.	.02
Apr. 17	4.7	8.00 A.M.	.32	.068	.18	2.3	10.00 A.M.	.10
May 2-3	24.3	7.40 A.M. of 2nd.	.86	.035	.51	3.3	8.00 A.M. of 2nd.	.18
May 3-4	5.3	10.00 P.M. of 3rd.	.14	.026	.13	4.3	10.40 P.M. of 3rd.	.03
May 10	3.0	5.00 P.M.	.30	.100	.27			
May 12	5.0	6.00 A.M.	.30	.060	.21	2.7	6.20 A.M.	.08
May 13	16.3	3.40 A.M.	.83	.051	.42	2.3	4.00 P.M.	.16
May 21	8.0	2.20 A.M.	.12	.015				
May 21	2.0	4 20 P.M.	.16	.080	.36			
May 25	4.3	12.40 A.M.	.72	.167	.51	1.0	12.40 A.M.	.48
May 28			.08					
May 30-31	9.0	10.20 P.M. of 30th.	.35	.039	.18	3.0	4.00 A.M. of 31st.	.10
June 4			.10					
June 9-10	25.0	5.00 A.M. of 9th.	1.30	.052	.30	8.0	12.00 M. of 9th.	.11
June 10			.18					
June 13-14			.46					
June 20-21	21.0	9.20 A.M.	.32	.015	.18	3.0	3 00 A.M. of 21st.	.09
June 30 31	24.0	10.00 A.M. of 30th.	.82	.035	.30	5.0	12.00 P.M. of 30th.	.11
July 13-14	48.0	10.00 A.M. of 13th.	2.56	.053	.90			
July 21	1.0	2.40 P.M.	.24	.240	.54			
July 22	10.0	7.00 A.M.	1.93	.193	.87	7.7	7 00 A.M.	.24
July 23	4.7	7.20 P.M.	.17	.036	.33	.7	7.20 P.M.	.18
July 24	1.0	11.40 A.M.	.10	.110	.21			
July 25	7 7	4 00 P.M.	.14	.018	.30			
July 29	7.0	2.00 A.M.	1.35	.193	1.20	3.0	4.00 A.M.	.36
Aug. 5	6.7	3.40 A.M	.65	.097	.36	5.3	3 40 A.M.	.12
Aug. 9	7.3	4.40 P M.	.28	.038	.60	.7	4 40 P.M.	.30
Aug. 11	2.3	8.40 A.M.	.10	.043	.11			
Aug. 15	4.7	3.20 P.M.	.18	.039	.42	.3	3.20 P.M.	.42
Aug. 16	2.3	4.20 A.M.	.34	.148	.33	2.0	4.20 A.M.	.16
Aug. 17			.03					
Aug. 18			.12					
Aug 22	8.0	4.20 P.M.	.36	.045	.48	1 7	4.20 P.M.	.19
Aug. 24	4.0	8.20 A.M.	.60	.150	.48	2.7	9.40 A.M.	.21
Sept. 2	11.0	4.20 A.M.	.78	.062	.36	3.7	4.40 A.M.	.14
Sept. 20			.10					
Sept. 23-24	13.7	8.00 P.M. of 23rd.	.47	.034	.21	3.3	8.00 P.M. of 23rd.	.08
Sept. 28	.7	6.40 P.M.	.30	.430	.84	.3	6.40 P.M.	.84
Oct. 11	8.3	11.40 A.M.	.34	.041	.39	1.3	12.00 M.	.23
Oct. 12	13.0	2.40 A.M.	.35	.027	.30	7.7	7.20 A.M.	.04
Nov. 1-2	32 0	3.00 P.M. of 1st.	2.60	.081	.42	22.0	5.40 P.M. of 1st.	.11
Nov. 9	16.7	3.40 A.M.	.70	.042	.30	12.3	4 00 A M.	.05
Nov. 11-12	13.7	8.20 P.M. of 11th.	1.38	.101	.24			
Nov. 15	6.3	6.00 P.M.	.28	.044	.24			
Nov. 20			*.13					
Nov. 22			*.21					
Nov. 26-27			.75					
Nov. 29			†.22					

* Snow. † Snow and rain.

[illegible]	[illegible]	[illegible]	[illegible]	2.0	7.40 P.M.	[illegible]
[illegible]	[illegible]	[illegible]	.2	2.7	[illegible] A.M.	.5
[illegible]	[illegible]	.42	.1	[illegible]	[illegible] P.M.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	5.0	12.00 M.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.40 A.M.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] A.M.	[illegible]
[illegible]	[illegible]	[illegible]	.2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] P.M.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] A.M.	.20
[illegible]	[illegible]	[illegible]	.39			
[illegible]	[illegible]	[illegible]	.57	0.3	3.40 P.M.	.57
[illegible]	[illegible]	[illegible]	.21	7	12.20 P.M.	.17
[illegible]	[illegible]	[illegible]	.39			
[illegible]	[illegible]	[illegible]	1.41	1.3	2.40 A.M.	.45
[illegible]	[illegible]	[illegible]	.54	2.7	7.20 A.M.	[illegible]
[illegible]	[illegible]	[illegible]	.21	1.7	[illegible] P.M.	.10
[illegible]	3 [illegible]	[illegible]	.03	14.0	2.00 P.M. of 10th.	.20
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	.21	1.3	1.20 A.M.	.12
[illegible]	[illegible]	[illegible]	.54	2.3	12.40 P.M.	[illegible]
[illegible]	[illegible]	[illegible]	1.41	.7	6.20 P.M.	.70
[illegible]	[illegible]	[illegible]	.24			
[illegible]	.31	115	[illegible]	.3	6.40 P.M.	.87

TABLE X.—*Continued.*

RAINFALL AT THE PURIFICATION WORKS DURING THE FISCAL YEAR OF 1898.

DATE.	DURATION OF STORM. Hours.	DURATION OF STORM. From	Total Precipitation in Inches.	Rate per Hour in Inches.	Rate per Hour for 20 Minutes of Maximum Precipitation in Inches.	PERIOD OF GREATEST PRECIPITATION. Hours.	PERIOD OF GREATEST PRECIPITATION. From	Rate per Hour in Inches.
Aug. 25	1.7	10.40 A.M.	.10	.069	.21	.3	10.40 P.M.	.21
Sept. 1	.7	5.40 P.M.	.43	.614	1.26	.3	5.40 P.M.	1.26
Sept. 2	3.3	7.40 P.M.	.13	.039	.35	.3	7 40 P.M.	.35
Sept. 7	3.3	4.20 P.M.	.55	.167	.90	2.0	4.20 P.M.	.26
Sept. 16	3.7	1.40 P.M.	.07	.019	.05			
Sept. 18	.7	4.00 P.M.	1.03	1.480				
Sept. 23	8.0	2.00 A.M.	.98	.123	.63	4.3	2.40 A.M.	.21
Sept. 24	1.7	11.00 A.M.	.19	.112	.30	.7	11.40 A.M.	.24
Sept. 26	1.3	10.40 P.M.	.14	.108	.27	.3	10.40 P.M.	.27
Oct. 5	15.3	3.20 A.M.	1.42	.093	.99	12.3	6.00 A.M.	.11
Oct. 8	6.7	2.20 A.M.	.17	.025	.11	3.3	5.40 A.M.	.05
Oct. 12	3.0	12.00 P.M. of 11th.	1.22	.407	1.08			
Oct. 14-15	11.3	7.40 P.M. of 14th.	1.00	.088	.70	6.3	8.00 P.M. of 14th.	.15
Oct. 19	11.7	10.20 A.M.	.90	.077	.38	9.0	11.00 A.M.	.09
Oct. 21-22	11.7	10.00 P.M. of 21st.	1.11	.095	.36	4.7	1.00 A.M. of 22nd.	.18
Oct. 26-27	16.3	11.00 A.M. of 26th.	1.10	.067	.54	2.7	12.00 M. of 26th.	.20
Oct. 29			.04					
Oct. 30			.07					
Nov. 6	6.3	5.20 A.M.	.20	.032	.27	1.3	6.00 A.M.	.12
Nov. 10-11	28.7	3.40 A.M. of 10th.	1.90	.066	.24	15.3	9.00 A.M. of 10th.	.12
Nov. 13	2.7	9.40 P.M.	.13	.048	.16			
Nov. 17	12.0	8.40 A.M.	.30	.025	.09	7.3	9.00 A.M.	.03
Nov. 18-19	26.7	7.20 P.M. of 18th.	1.28	.048	.15	21.0	8.00 P.M. of 18th.	.06
Nov. 24	13.3	10.00 A.M.	†.50	.038	.20			
Nov. 26-27			*1.25					
Nov. 30	12.0	5.40 A.M.	*1.12	.093	.36	9.3	7.20 A.M.	.12

*Snow. †Snow and rain.

[illegible]	[illegible]	[illegible] P. M.	.43
[illegible]	[illegible]	3.[illegible] A. M.	.43
[illegible]	[illegible]	[illegible] A. M.	.33
[illegible]	4.3	1.00 P. M.	.07
.30			
.54	6.3	4.00 P. M.	.09
.33	2.7	11.30 P. M. of 3rd.	.14
.12	13.0	12.00 M. of 11th.	.08

CONSTRUCTION.

An unusually large amount of work has been done in the department of sewer construction, consisting of the building of 6.9 miles of sewer.

The adoption of the separate system of sewers made necessary, in future construction, the building of two sewers in every street, one for sewage and the other for surface water. With the combined system one large pipe received both sewage and natural drainage. To meet the needs of the new system, the experiment has been tried of laying both pipes in the same trench, one enough higher than the other to admit the laying of house connections under it.

By this method the two pipes are laid at a slightly greater cost for excavating than one pipe should be. The trench being sufficiently wide is carried along with one set of sheathing and bracing, when a second set would be necessary if two trenches were dug. One underdrain suffices for both sewers, and the street is torn up but once and in only one place. The only doubtful factor in this method is the power of the upper pipe to stand the unequal pressure due to settlement of the loose material over the lower pipe. The trench is dug at full width until it is nearly deep enough for the upper pipe. Then a narrow trench is dug on one side of the main trench to the grade of the lower pipe. This pipe is laid as usual, and the back filling very carefully tamped up to six inches or a foot above the upper pipe. From this point up the trench is filled and tamped or puddled in the ordinary manner.

A large territory has been accommodated by the construction of sewers in Winthrop street, Granite street, Wabash avenue and South Stowell street. The sewering of this section of the city has been agitated for nearly ten years.

An important move has been made toward the sewering of Greendale by the construction of the sewer in Grove street and West Boylston street, a distance of about 5,000 feet. James Kerwan has been the foreman in charge of this work.

The development of building sites in the vicinity of Pleasant street, beyond Newton square, has made the sewering of this locality a necessity. Although this is a newly improved district, there are many residences along the line which can be connected. The building of the sewer in Pleasant street necessitated a deep excavation through ledge opposite the old cemetery. This work occupied a long time, and the patrons of the street railway company were subjected to considerable inconvenience on account of having to change cars. They were, however, very forbearing, and their patience was duly appreciated. Thomas Mulhern was foreman in charge of this work.

A sewer has been built through Crompton and Brussels streets, and, although the sewer itself is small and of no particular interest, it is a very important addition to the system. It is now possible for the extensive carpet mills of Mr. M. J. Whittall and the Worcester Carpet Co. to discharge their sewage into the sewer instead of into the river, as has been done up to this time. The section of the river for half a mile below these mills has gradually become a nuisance on account of the foul odors arising from it during the summer months. With the stopping of the discharge of the sewage into its waters there should be a marked improvement in this respect.

The sewer in Ballard street was completed during the winter and affords an opportunity for the sewerage of the south works of the American Steel & Wire Co. This was an expensive sewer because it was quite deep and the excavation was through rock which had absolutely no cleavage, and for that reason was very difficult to work. In addition to this the ground was full of water, and while the soil was such that a large amount of water did not drain from it, there was enough to make the work very tedious and uncomfortable.

It is expected that no unfinished work will be left over until spring, so that the entire income of the new year may be devoted to work ordered during that time.

This branch of the work of the department has comprised the building of 5.34 miles of sewers, 1.56 miles of surface water drains, and 244 man-holes. Only 1,241.2 feet of brick sewer have been built.

About the usual number of house connections have been made during the year. Four hundred and twenty-three permits for this work have been taken out, of which 97 were for surface water, 9 for repairs, and 31 were not used.

Following is a brief schedule of the property owned by the department:

Personal property,	$47,436 62
Hammond street, 1,700 feet of land,	425 00
East Worcester street, building and machinery,	2,700 00
Purification works, land	54,016 75
Buildings and machinery,	32,925 00
Total,	$137,503 37

Tables XII and XIII give in detail the location and sizes of the various sewers constructed, both in the department of construction and that of separation.

The buildings at the purification works are in fairly good condition. At East Worcester street the building used as a shop is in poor condition, little repairing having been done, as it was expected to obtain better accommodations in the near future. All tools and machinery are in proper condition.

SEPARATING SYSTEM.

The separating system, upon which a large amount of work has been done during the past year, is fully explained in the plan filed with the court in 1897. It consists of one main interceptor for sewage inside Millbrook from the outfall sewer to Cambridge street. From this point two interceptors parallel Millbrook throughout its entire length with the necessary regulating apparatus for controlling the admission of surface water.

Considerations of grade have also necessitated extensive changes in the sewer system of Cambridge, Washburn, Southbridge and Southgate streets. The construction of the main carrier in Millbrook made it seem wise to divert the surface water of South Worcester and the west side of the city from the existing system into adjacent water courses.

The work of separation has been progressing continuously since it was first started in July, 1897, and during the past

TABLE XII.

Record of Sewers Constructed during the Fiscal Year of 1899.

SURFACE WATER SYSTEM.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.	Cost.	Estimate
Pleasant,	Beeching westerly,	16 x 24 18 oval 15	245.1 767.5 220.0	5	$2,657 44	$1,980 0
Beeching,	Pleasant northerly,	15 12	449.5 522.9	3		
Lenox,	Pleasant northerly,	12	884.6	2		
Noyes,	Pleasant southerly,	12	26.5	1		
A new street,	Pleasant southerly,	12	26.9	1		
Park avenue,	Chandler to Hudson court, W. S.,	24 x 36 20 x 30	823.0 429.0	8	3,921 33	
Shawmut,	Russell to Merrick, W. S.,	12	260.4	3		
Russell court,	Russell westerly, W. S.,	12	363 9	3		
Merrick,	Pleasant to Elm,	46 43⅝x49	46.6 689.9	4	744 52	
Elm,	Merrick to Sever,	43⅝ x 49	291.1	2		
Sever,	Curve into Elm,	43⅝ x 49	28.0			
Pleasant,	Piedmont to West, W. S.,	12	731.4	8	1,762 78	
Mass. avenue,	Salisbury southerly,	15 18	367.0 438.5	2		
Rutland terrace,	Salisbury southerly,	30	565.9	4		
Metcalf,	Mass. avenue to Rutland terrace,	12	312.5	2		
Highland,	Germain to Haviland, W. S.,	12	274.5	2	499 86	
Haviland,	Highland northerly,	12	39.7	1		
Bigelow,	Lafayette to Sigel,	15 12	220.4 254.8	4		
Ellsworth,	Bigelow easterly,	12	30.5	1		
Sigel,	Bigelow easterly,	12	30.1	1		
Commercial,	Exchange southerly,	12	275.6	3		
"	Central "	12	199.8	2		
"	Central northerly,	12	267.9	3		
"	Thomas "	12	236.6	2		
Chelsea,	*Crompton to Cheever,	15	250.1	2	980 08	
Cheever,	*Chelsea to Woodward,	12	553.0	4		
Meade,	Extension to Lamartine,	12	297.1	2		
Institute road,	West westerly, W. S.,	12	36.8	1		
Agricultural,	Elm northerly, W. S.,	34 x 51	909.0	5	5,937 01	
William,	Sever to Agricultural,	20 15 12	270.1 299.9 199 0	5		
Somerset,	William to Highland, Private,	15 12	377.5 516.7	6		
Roxbury,	William to Highland,	15 12	426.9 481.6	6		

NOTE.—All streets marked W. S. come under the West Side orders for surface and sanitary sewers, the estimate of which is $105,400.

NOTE.—Costs which are omitted in this table are included in those in the table of sanitary sewers for streets of the same name.

*Under order of Crompton and Brussels.

TABLE XIII.

Record of Sewers Constructed during the Fiscal Year of 1899.

SANITARY SYSTEM.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.	Cost.	Estimate
Cambridge.	Quinsigamond Ave. to Washburn St.	32 x 42	1,537.1	6	$30 040 38	$29,430 00
Washburn,	Cambridge to Southbridge,	24 x 30	1,026.1	4		
Southbridge,	Washburn to Hammond,	18	1,107.4	10		
		24 x 30	681.6			
	Southgate, northerly in E. sidewalk.	8	500.2	5		
Hammond,	Southbridge to Canterbury,	18	28.1	4	22,031 28	41,360 00
		15	331.5			
		8	49.0			
Canterbury,	Hammond, southerly,	12	701.5	7		
		10	208.6			
Southgate,	Southbridge to railroad,	20	340.1	2		
Millbury,	Sigel to Vernon square,	48	658.8	7	33,604 34	38,700 00
		32 x 42	717.2			
Water.	Millbury to Ledge.	40 x 54	1,446.0	3	47,634 99	79,000 00
Washington.	Between Lafayette and Bradley.	32 x 42	523.2	3		
Bradley.	Washington to Green,	32 x 42	532.4	1		
Lafayette.	Quinsigamond Ave., westerly,	8	309.4	3		
Lunelle.	Lafayette, northerly,	8	31.4			
Langdon,	" "	8	326.5	4	29,604 96	34,331 00
Lodi.	" "	8	207.0	2		
Grosvenor,	" "	8	68.2	2		
Meade.	" "	8	291.7	3		
Scott.	" "	8	335.0	3		
Green,	Bradley to Pond,	32 x 42	864.3	4	63,872 83	40,000 00
Lamartine.	Quinsigamond Ave. to Lodi,	32 x 42	287.5	7		
		10	732.6			
Sargent,	Lamartine to Southbridge.	32 x 42	514.1	2	18,737 71	26,764 00
Gold.	Sargent to Assonet,	15	979.1	12		
		12	24.0			
		8	992.0			
Commercial,	North Foster to School,	24 x 30	731.5	7	12,242 91	25,510 00
		24	663.4			
Bartlett place,	Extension to Franklin,	12 (c)	218.8	3	784 70	330 00
Rodney,	Vinson, southerly,	10	226.0	2	455 71	485 00
Fruit.	William, southerly, W. S.	8	162.1	1	957 98	
	William, northerly, W. S.	8	360.0	2		
Institute road,	Boynton to West,	8	578.8	5	576 69	780 00
William.	Sever, easterly, W. S.	8	734.0	5	1,560 61	
Orient,	Extension easterly.	8	245.9	2	1,293 29	600 00
Pleasant,	Russell to Merrick, W. S.	18	291.8	2	6,631 82	
Merrick,	Pleasant to Elm,	18	738.5	4	12,313 04	9,890 00
Elm,	Merrick to Sever,	18	283.1	2		
Sever,	Elm to Highland, W. S.	18	385.9	10		
		15	748.2		7,513 87	
		12	666.5			
Pleasant,	Cemetery, westerly,	22 x 33	430.2	21		
		15	969.4		11,955 77	8,420 00
		12	980.5			
		10	987.5			
Beeching.	Pleasant, northerly,	8	962.4	3	3,624 92	2,060 00
Lenox,	Pleasant, northerly.	8	884.6	3	1,762 75	2,450 00
Mass. Ave..	Salisbury, southerly,	8	797.3	3	2,911 57	1,400 00
Rutland terrace,	Salisbury, southerly.	10	559.6	4	2,618 57	2,896 00
Metcalf.	Mass. Ave. to Rutland terrace,	8	312.5	2	637 20	635 00
*Crompton,	Southgate to Brussels,	15	160.7	3		
Brussels.	Crompton, southerly.	15	409.5	6	1,870 67	3,323 00
		10	337.3			
Hadwen road.	June to Fiske,	8	361.1	3	2,051 38	2,300 20
Fiske, .	Hadwen road, southerly.	8	872.8	5		
Endicott.	Quinsigamond to Millbury,	8	1,125.8	6	725 45	1,295 00
Fruit.	Pleasant, northerly, W. S.	8	187.9	2	257 80	
*Jaques avenue,	At City Hospital,	12 (c)	57.6	2	138 74	
College,	Caro to Clay.	12	354.5	2	1,090 62	1,140 00
Clay,	College, southerly,	8	440.6	3		
Winthrop,	Extension to Granite,	10	1,091.5	8		
Granite,	Winthrop, southeasterly,	10	1,037.1	10	4,007 13	5,554 00
		8	216.8			

TABLE XIII.—*Continued.*

Record of Sewers Constructed during the Fiscal Year of 1899.

SANITARY SYSTEM.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.	Cost.	Estimate
Wabash avenue,	Granite, southerly,	8	443.9	2		
South Stowell,	Granite, northerly,	8	260.9	3		
Arlington,	Extension southerly,	8	254.3	2	$601 69	$520 00
Vernon,	Extension southerly,	8	536.3	4	1,184 14	840 00
*Plantation,	Hamilton, northerly,	18	162.4	2		
Mars,	Louise to Esther,	8	402.2	3	423 42	480 00
Grove,	Extension to Chadwick square,	18	2,483.7	17	20,579 01	18,900 00
West Boylston.	Grove, northerly,	15	2,137.3	14		
Lancaster place,	Lancaster, westerly,	8	160.9	2	205 20	210 00
Stanton,	Vinson, northerly,	10	222.0	2	295 55	390 00
Everard,	Vinson, northerly,	8	100 2	2	212 49	176 00
Blake,	Fox to Columbia,	8	177.2	2	190 98	250 00
Eastern avenue,	Berkeley to Prospect,	8	208.3	3	626 63	850 00
Muskeego,	Shrewsbury, southerly,	10	527.9	5	465 81	1,040 00
Ballard avenue,	Millbury, southeasterly,	18	1,776.0	18	14,109 66	7,670 00
		15	171.5			
Marie avenue,	Burncoat, westerly,	10	977.1	6	1,303 44	1,480 00
William,	Sever to Agricultural,	8	763.0	5	2,630 59	
Somerset,	William to Highland (private),	8	899.1	5	1,999 14	
Roxbury,	William to Highland,	8	917.6	6	1,584 59	

* Reconstructed.

NOTE.—All streets marked W. S. come under the West Side orders for surface and sanitary sewers, the estimate of which is $105,400.

year an average of about 300 men has been employed upon it. This does not include the force engaged in the construction of the filter beds at the purification works.

In the sections of the city where the separating system is being constructed, it has been necessary to change many house connections from the old sewers, to be used for surface water in the future, to the new ones. In such cases the owners of the property have been notified that the change was necessary, and that if they desired, the department would do the work free of charge to them.

In a few of these cases it has been found that the plumbing in the houses was too low to be connected to the new sewer, and consequently it will have to be raised. This the department has not undertaken to do, and has served notices upon the owners accordingly.

There yet remains to be done somewhat more than can be accomplished in one year, although if progress is not delayed for lack of funds or some unforeseen reason, there will be but little to be completed after next fall.

It is important that this work should be finished without delay for several reasons:

First: The city is under moral obligations to proceed in good faith and as rapidly as is consistent with economy and good workmanship on account of its report to the Supreme Court.

Second: The money already expended is doing and can do practically little good until the system as outlined to the court is complete or nearly so.

Third: The annual expenditure for the purification of the sewage, while by no means without beneficial results, is not accomplishing what it could if the treatment was not so severely handicapped by the enormous amount of clean water drawn from North and Salisbury ponds.

Fourth: It would seem to be an argument of no little importance that the streets which it is known must be disturbed for this purpose in the near future should receive attention as soon as possible, so that they may be permanently improved as occasion may demand.

Another reason, although of not as much importance as those mentioned above, is that the department is at present organized for the large amount of work it has been called upon to do during the last two years. If the work of separation should be delayed for one year it would be necessary either to carry the present organization, at considerable expense, or cause further delay and entail additional expense of reorganization.

During the past year $326,179.77 has been expended upon this work, leaving a balance Dec. 1, 1899, of $63,724.09, which is all the money available, the entire amount authorized by the special statute of 1897 having been appropriated.

It should be mentioned in this connection that $330,000, which had been borrowed previous to the passage of this statute, for the construction of the outfall sewer and the purification works, was made, by virtue of this act, a part of the authorized loan of $1,000,000, so that the actual amount of money thus far expended upon the separating system is but about $600,000, including the construction of filter beds and payment of land damages.

It will be necessary to obtain more money from some source, and this should be done at the first opportunity, that there may be no delay in prosecuting the work.

As a full report has never been made upon the progress of this work it seems desirable that this account should cover everything accomplished from the beginning.

CONDUIT INSIDE MILLBROOK.

Length, 3,660 feet.

Size (see Cut B).

Estimated cost, $45,450.00.

Cost, $43,875.80.

Work begun, July, 1897.

Work finished, April, 1898.

Engineer in charge of electrical and mechanical engineering, Robert N. Cundall.

Foreman, James Mulhern.

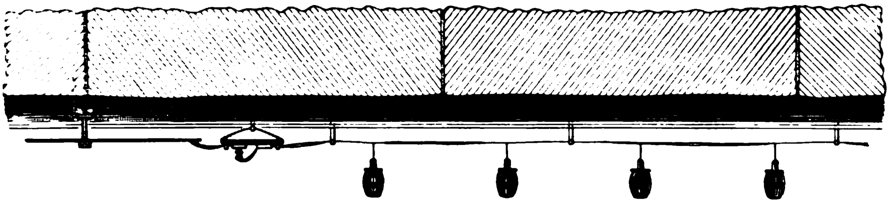
The trunk sewer in Millbury street, between Cambridge street and the Blackstone river, a distance of about 4,000 feet, is built of stone, and is 18 feet wide and 13 feet high. The arch has a four-foot rise and springs from the top of vertical walls five feet high.

The invert is also circular and of the same dimensions as the arch. This sewer was designed to take sewage and surface water from a very large portion of the city. It was laid through ledge and occupied so large a proportion of the street that it was deemed impracticable to parallel it with interceptors.

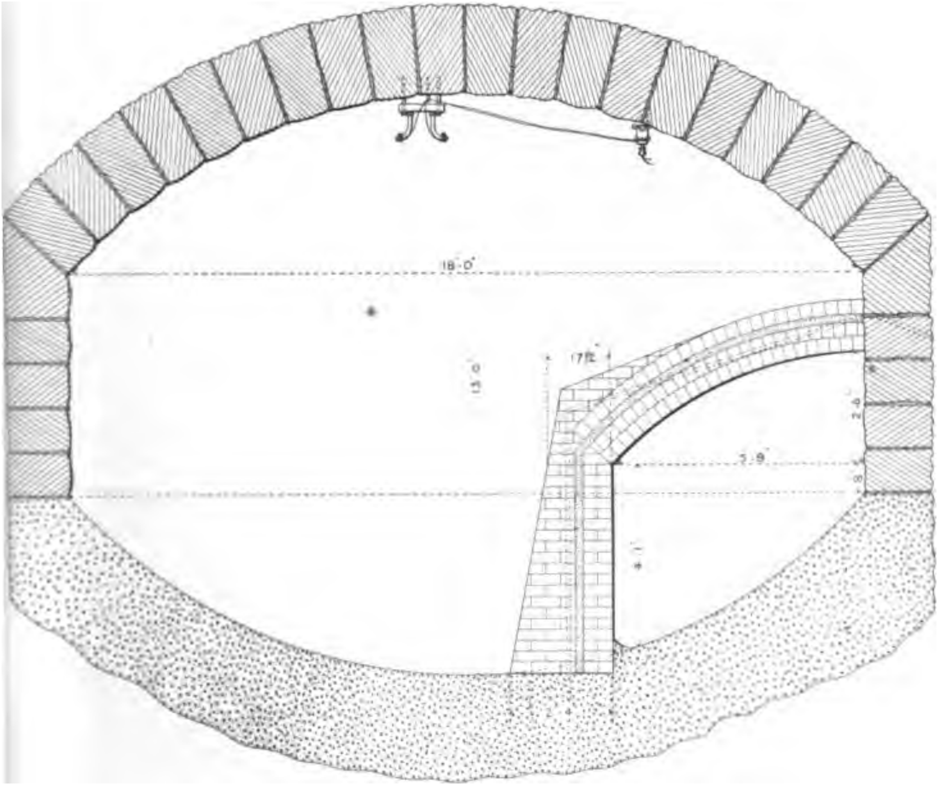
Accordingly a conduit was designed to accommodate the flow of sewage inside the large sewer, a sufficient area in the southern and western sections of the city being resewered to discharge surface water directly into adjacent water courses to make room in Millbrook for the new construction.

This conduit has a capacity of about fifty million gallons per twenty-four hours, and extends from the outfall sewer nearly to Cambridge street, a distance of about 3,660 feet.

For obvious reasons it was not practicable to remove the arch of the sewer and build the new work in open cut as in ordinary



LIGHT STRINGS.



INTERIOR OF MILLBROOK.

CUT B.

SKETCH OF MILLBROOK SEWER SHOWING INTERCEPTING CONDUIT AT RIGHT. METHOD OF LIGHTING SHOWN ABOVE.

grade sufficient to allow stock-cars to descend by gravity. This incline was extended through the centre of the power-house to the rear of the lot where the brick could be loaded. Cement was loaded from the store-room, and sand was taken into the cars through a chute in the hopper, into which it was dumped from the street. Coal was also dumped onto an incline from the street, the foot of which came nearly to the boiler door.

LIGHTING.

The air in the sewer was very warm and impure, and proved to be rather debilitating. It was necessary, therefore, to guard against increasing impurities and temperature. For that reason the use of steam or torches was avoided and electric light and power were used entirely.

A potential of 220 volts was fixed upon as being perfectly safe in case bare wires were taken hold of by the men, and also as not requiring an extravagant amount of copper for conductors or presenting serious difficulties in the way of insulation. The insulation had been a subject of some misgiving, as the air was very damp, but the method shown in Cut B proved very efficient, there being at no time a serious leakage. The current was taken through the tunnel from the switch-board by two well insulated mains, which were attached to two No. 00, hard-drawn, bare, copper wire or ordinary trolley wires, which extended from the power-station to the end of the work in one direction. These bare wires were fastened to the arch of the sewer by clamp-hangers secured to wooden cleats, which were suspended from hooks driven into the masonry. These fixtures are shown in Cut B. These hangers were put in once in fifty feet, and a 10-c. p. lamp was fastened to each to furnish light for the boats passing up and down.

The work was lighted by 16-C. P. lamps attached, one in every three feet, to light strings. These strings were thirty feet long, and consisted of two No. 14 insulated wires fastened at one end to a board, 4x16 inches, which was provided with a fuse-box and switch. Tail wires extended from this switch-board to the copper mains, to which they were attached by mechanical clamps. These light strings were hung on hooks driven into

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at times of severe storms it was so deep that it submerged all the work and coffer dam, and once or twice the sewer was nearly full. Usually there was little current, and the cause of the depth of water was the dam at the lower end of the sewer which backs the water up, thereby forcing it through the outfall sewer to the purification works.

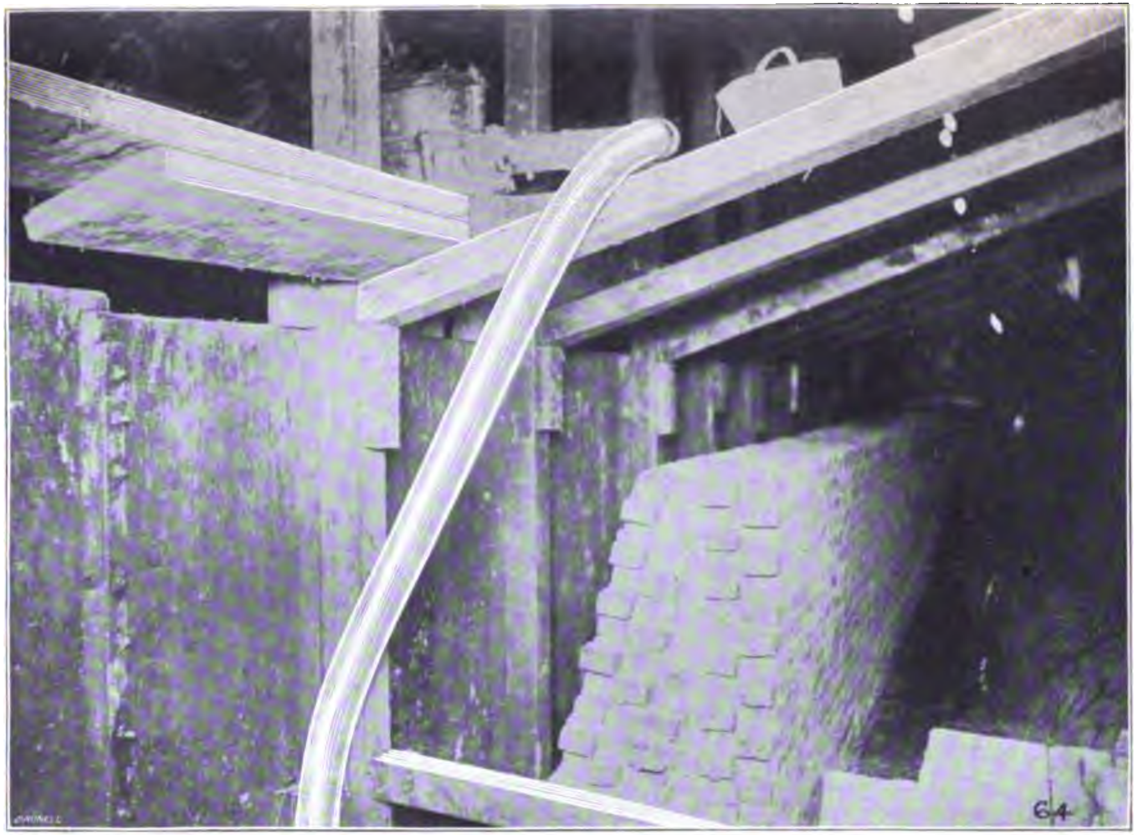
A coffer-dam was erected around the work, which kept the water out almost completely. It was built in sections 6 feet high and 16 feet long, of 2-inch tongued and grooved spruce plank. These sections were suitably cleated with 6-inch strips of plank, and on each end was fastened a strip of 2½x½-inch iron, which had bolt holes drilled in it. On the bottom of each section a 2x6-inch sill was fastened, and the under side of this had a wad of oakum attached and was protected by a covering of burlap.

These sections were placed in an upright position upon the properly cleaned invert and securely fastened by means of lag-screws to posts, wedged tightly between invert and arch. The sections of dam were bolted to each other through the iron strips mentioned. Diagonal braces, as seen in Cut D, were driven between the upright posts at the top of the dam and the springing line of the sewer to withstand the external pressure of the water. The foot of each post was also securely braced to prevent movement due to pressure. Bulkheads were placed at each end of the enclosure. (See Cut E.) As the work progressed the coffer-dams were taken down, carried forward and placed in position for the continuance of the construction.

All work done upon the coffer-dams had to be done between 10 o'clock Saturday night and 7 o'clock Monday morning, and it required most of this time to place a sufficient amount of coffer-dam for a week's work.

PUMPING.

For pumping the large amount of water which had to be removed from the coffer dam when first erected and after overflow caused by storms, a four-inch centrifugal pump was provided. It was placed in a scow and belted direct to a 10-H. P. mining motor of enclosed type made by the General Electric Co.



CUT D.

Section of Side Wall to Conduit in Millbrook Showing Coffer Dam, and Method of Bracing the Same.

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The power was obtained from the copper mains by temporary connection of flexible cables. With this apparatus the water was quickly pumped, and the whole was easily moved ahead as progress required.

CONSTRUCTION.

After all preliminary work had been done, the construction of the conduit was a comparatively simple operation. The invert was cut out just enough to form a level footing for the side wall, then anchor-irons were placed in position and fastened, and the side wall and arch were built. Eight inches from the inside face of the wall a 2-inch core of cement mortar was laid, and this was carried through the arch without break. This was to insure as nearly water-tight work as possible. The outside of the conduit was plastered with cement mortar and left smooth. Connections through the original sewer on this side were taken into the conduit through its arch as seen in Cut F, as they almost invariably entered above it.

The side wall was 2 feet 4 inches thick at the bottom and 1 foot 6 inches at the top. It was 4 feet 3 inches high. The arch was about 14 inches thick, including core, as shown in sketch Cut B.

On this work about 1,300,000 hard-burned, water-struck brick and about 10,000 barrels of Atlas American Portland cement were used.

Manholes were set in the arch at frequent intervals to facilitate cleaning and inspection.

Under the best of conditions a progress of thirty-two feet per day was made, but the delays were frequent and at times of considerable length, so that about seven months' time was occupied in the construction of this conduit.

SYPHONS—QUINSIGAMOND AVENUE AT CAMBRIDGE STREET.

Length, 256 feet.
Average depth, 21.5 feet.
Size, three 30-inch cast-iron pipes in each syphon.
Estimated cost, $39,512.00.
Cost, $32,171.93.

Work begun, July, 1898.
Work finished, February, 1899.
Foreman, James Mulhern.

The connection of the east and west interceptors with the Millbrook conduit was somewhat complicated by the fact that the interceptors were of necessity kept so low that it was impossible for them to be carried over the existing sewers at Cambridge street. As the conduit was on the west side of Millbrook it was necessary for the east interceptor to pass under Millbrook before connecting. To accomplish this a syphon was built, the depression of grade being about six feet. A main collecting chamber was built on the west side of Millbrook at a convenient point for connection with the new conduit; from this three cast-iron pipe syphons were laid under Millbrook, as shown in Cut G, and connected with the gate chamber about 10 feet by 11.5 feet into which the east interceptor discharges. These syphons are thirty inches in diameter, and consist of ordinary light-weight water-pipe laid in Portland cement concrete. Each pipe was provided with gates at both ends, as well as a manhole for inspection and repairs. The syphon is about fifty feet long.

The syphon connecting the collecting chamber with the west interceptor is of practically the same construction, and is about 206 feet long. This syphon passes under the old sewers for Quinsigamond avenue and Cambridge street, which enter Millbrook practically at the bottom of its invert.

The gate and collecting chambers were built entirely of Portland cement concrete, with roofs of I-beams and concrete arches. Considerable water was encountered during this work, and was handled by means of a 6-inch centrifugal pump.

WEST INTERCEPTOR—SECTION IN QUINSIGAMOND AVENUE.

Length, 2,440 feet.
Average depth, 12.5 feet.
Size, round; 48 inches in diameter.
Estimated cost, $32,500.00.
Cost, $29,792.71.
Work begun, April, 1898.
Work finished, September, 1898.

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CUT E.

Foremen, James Mulhern, April to July; Timothy Connor, July to September.

The district through which this section of the west interceptor was constructed is very low and the ground was full of water. The excavation was largely in sand, which was fine enough to run when the water level was reached, although it could hardly be called quicksand.

A section of peat was found near Endicott street, which extended considerably below grade. Where it was not more than ten feet below grade, it was removed and the trench refilled to grade with good material well puddled and tamped. For a short distance the peat was too deep to remove and a timber platform was constructed of 4x12-inch spruce timber well tree-nailed, and upon this the sewer was constructed as usual, except that a somewhat thicker foundation of concrete was used. In building the invert of this sewer the trench was filled with Portland cement concrete to a subgrade four inches below the finished water line. The sides were then carried up to about five inches above the springing line of the arch, forming the invert of proper shape, and allowing for a single course of brick lining. The outside of the concrete extended to the sheathing-plank, these being plumb instead of following the curvature of the inside. After the concrete had become hard, the brick lining was put in. This consisted of a single ring of hard-burned, water-struck brick laid in Portland cement. The arch was two course-work of the same materials as had been used in the invert, and was plastered on the outside with Portland cement mortar. After the centres were drawn, the work was properly scraped and cleaned, after which it was washed with two coats of neat Portland cement.

This method of construction has been followed on all work done on the intercepting system.

The water was carried in the underdrain to a pump-well, from which it was pumped by a 6-inch centrifugal pump.

WEST INTERCEPTOR—SECTION IN LAFAYETTE, WASHINGTON AND BRADLEY STREETS.

Length, 2,638 feet.

Average depth, 15 feet.

Size, 32x42 inches.

Estimated cost, $34,331.00.

Cost, $29,604.96.

Work begun, September, 1898.

Work finished, November, 1899.

Foremen, Timothy Connor, on interceptor; Frederick C. Dearborn, William C. Shute and Thomas C. Davis, on connections and changes in side streets.

The continuation of the west interceptor from Quinsigamond avenue followed immediately the completion of the section in that street. The material excavated was largely sand in Lafayette street and hardpan in Washington and Bradley streets. Some ledge was excavated in Lafayette and Washington streets. New sewers were constructed in Lunelle, Langdon, Lodi, Grosvenor, Meade and Scott streets, and the old sewers were left as a part of the surface water system. This necessitated changing all the house connections from the old sewers into the new ones. Surface water drains were constructed in Bigelow, Sigel and Ellsworth streets, and the old sewers were connected with the interceptor. Little difficulty was caused by the ground water in this section.

WEST INTERCEPTOR—SECTION IN GREEN STREET FROM BRADLEY STREET TO TUNNEL.

Length, 180.3 feet.

Average depth, 18 feet.

Size, 32x42 inches.

Estimated cost, $40,000.00 (complete from Bradley to Franklin street.)

Cost, $3,268.57.

Work begun, June, 1899.

Work finished, September, 1899.

Foreman, Timothy Connor.

This section of the interceptor was built of the same material and in the same way as those already described. The material excavated was hardpan, and little trouble was caused by

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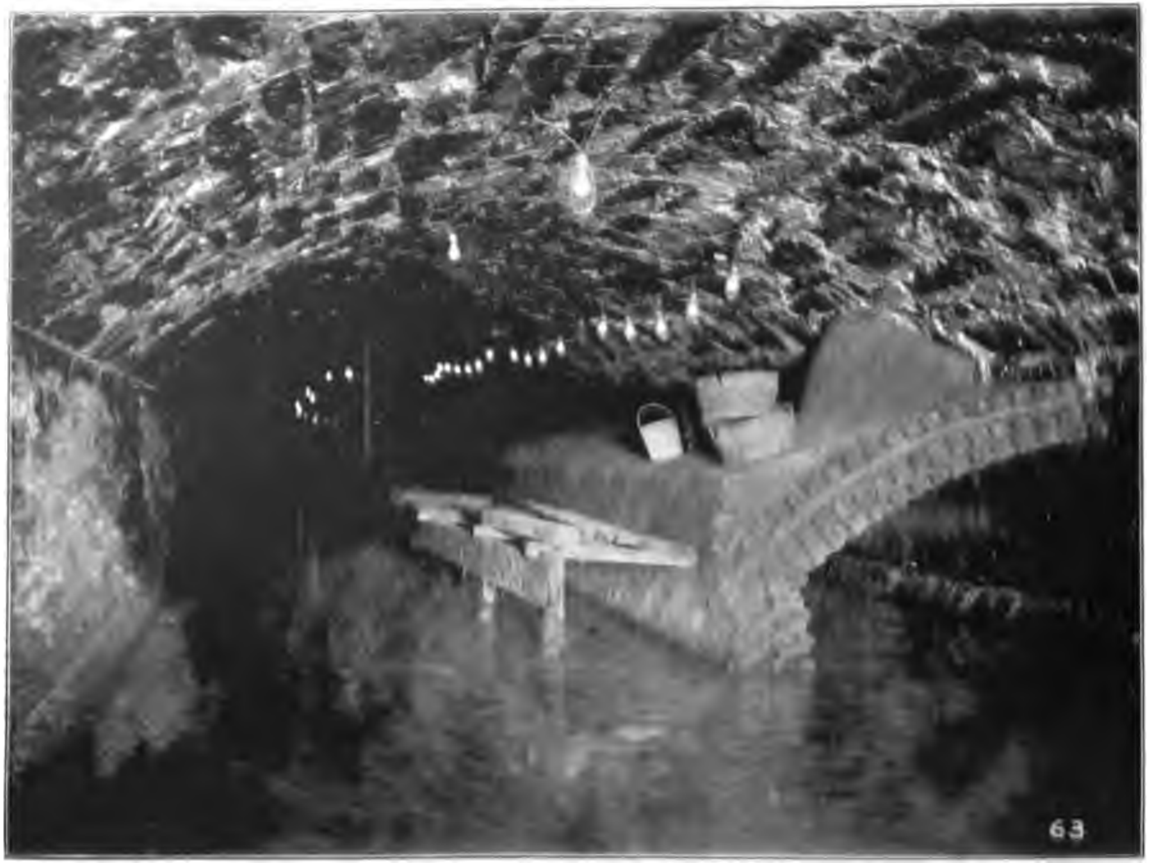

CUT F.

Section of Finished Conduit Showing Entrance of House Connection, Trolley-wires ground water. At the end of this section the sewer was connected with that built in the tunnel during the winter.

WEST INTERCEPTOR—SECTION TUNNELED IN GREEN STREET, SOUTH OF HARRISON STREET.

Length, 434 feet.

Average depth, 23 feet.

Size, 32x42 inches.

Estimated cost, $40,000.00 (complete from Bradley street to Franklin street).

Cost, $11,371.46.

Work begun, December, 1898.

Work finished, April, 1899.

Foremen, James Kerwan, day shift; Timothy Connor, night shift.

The grade of the interceptor through this section was so deep that it was considered advisable to proceed by tunneling. The street is very narrow, and the open trench method could not be used without causing serious inconvenience to the public. A shaft 8 feet by 16 feet was sunk at the corner of Harrison street, and headings were started from each end of it. As the material was hardpan, polling boards were used on roof and sides. The earth was very compact and the excavation was generally kept about three feet ahead of the timbering, which consisted of the usual cap pieces and legs 2.5 feet apart, as shown in Cut H. The roof plank were laid level from timber to timber after excavation was complete, and the sides were protected by plank laid horizontally from leg to leg. For a part of the distance the south heading ran through a loose gravel. In this material it was necessary to drive the roof and side plank slightly ahead of the work to prevent removing more gravel than was necessary. This method is illustrated by Cut I.

The north heading ran into a very wet mixture of coarse sand and clay, underneath which, at about grade of cut, was a stratum of extremely fine sand, which took on a semi-fluid condition as soon as it was walked upon, or disturbed in any other similar way. As soon as this material was discovered, further tunneling in this direction was abandoned and the work confined to the south heading.

Electric-light wires were run into this tunnel, and the heading was lighted by incandescent lamps. An electric motor car was used to carry the stock from the shaft to the point of use. The method of lighting and transportation is more fully treated in the description of the power-station on Water street.

Compressed air was used on this section only for pumping water. The exhaust air from the pump was taken to the heading to furnish fresh air, as there was practically no ventilation through the ground.

Ground water did not prove to be a serious trouble in this tunnel, although it was necessary to underdrain the work.

The methods and materials of construction were the same as described in the previous work.

Special care was taken to pack the back filling so that future settlement would be reduced to a minimum. The concrete of the invert was extended to the timbering on the sides, but Rosendale cement was used beyond the required thickness of the sewer. Cut I shows masonry as laid in tunnel, as well as the method of bracing used.

WEST INTERCEPTOR—SECTION IN GREEN STREET BETWEEN HARRISON AND POND STREETS.

Length, 250 feet.

Average depth, 25 feet.

Size, 32x42 inches.

Estimated cost, $40,000,00 (complete from Bradley to Franklin street).

Cost, $6,577.92.

Work begun, July, 1899.

Work finished, October, 1899.

Foreman, Hugh Montgomery.

This section of the interceptor was constructed in open cut because of the difficulty experienced in drifting, as explained in connection with the description of the north heading of the tunnel started at Harrison street. The ground water did not

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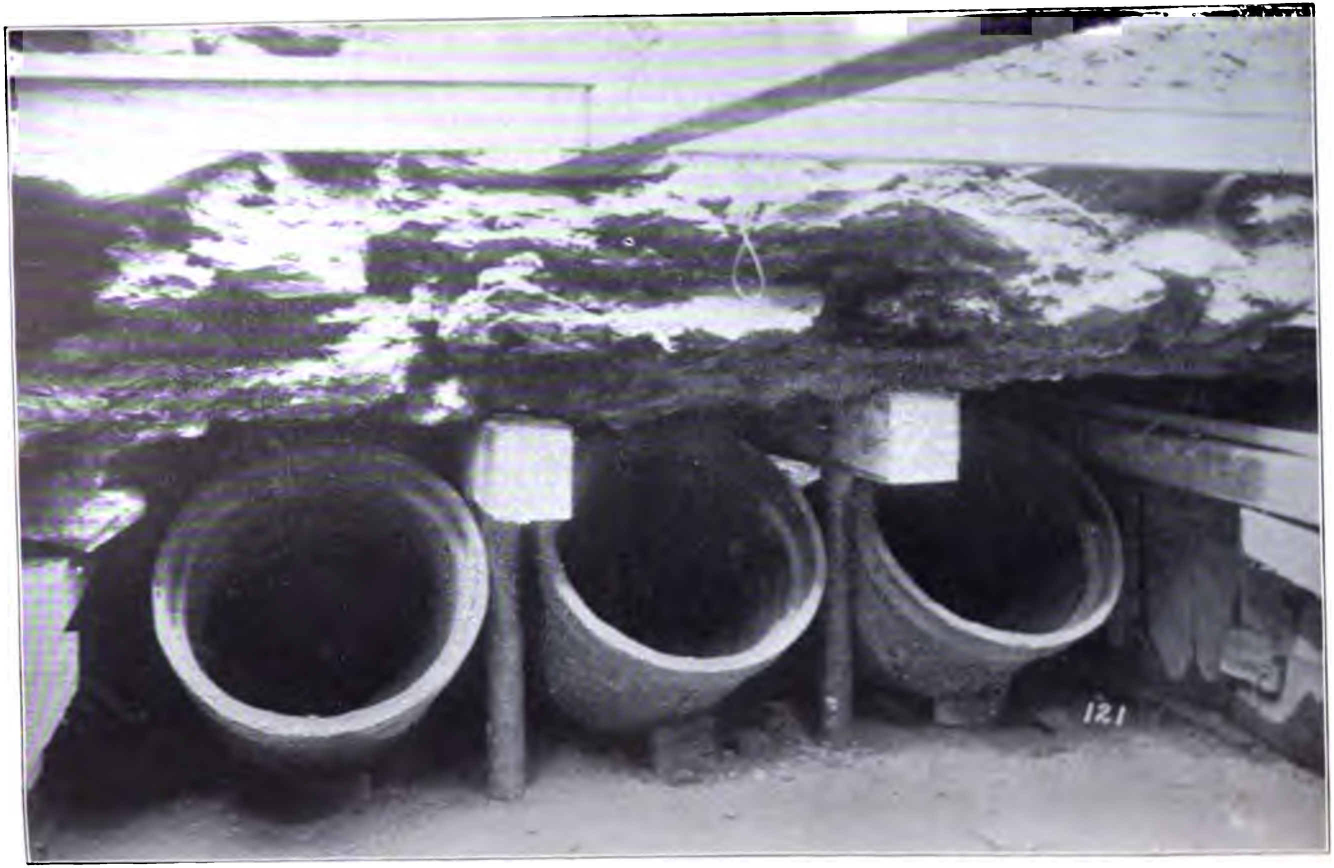

CUT G.

cause very serious trouble of itself, but was sufficient to make the excavation in the quicksand very difficult. The quicksand was very fine, and was within ten feet of the surface of the ground. Tongue and groove sheathing was driven considerably below grade by a steam plank-driver, made by the Ingersoll Sergeant Drill Co. Progress was extremely slow, as it was not possible to work in the sand more than a few minutes at a time before the material became so soft that further work had to be abandoned until it had become hard again. The trench was opened in short sections, but the excavation proved so expensive that open cutting was abandoned, and the pneumatic tunnel described later was extended south to the end of this trench.

TUNNEL THROUGH QUICKSAND—GREEN STREET.

Location: Green street, from Pond street to Franklin street, thence through Bartlett place and Cherry street nearly to Vine street.

Average depth, 27 feet.

Length, 1,480 feet.

Size: Diameter of drift, 6 feet 1½ inches; diameter of inside safety lining, 4 feet 10 inches; dimensions of finished sewer, 32x42 inches.

Estimated cost, $40,000.00 (complete from Bradley street to Franklin street).

Cost, $40,696.94.

Work begun, March, 1899.

Drifting finished, November, 1899. (Over 1,100 feet of lining to be put in.)

Constructing engineer in charge of work, Charles C. Lovejoy.

Engineer in charge of electrical engineering, Robert N. Cundall.

Foreman on day shift, James Mulhern.

Foreman on night shift, John Diamond.

When it was learned that the material in Green street was unfit for tunneling by ordinary means, studies were at once begun to determine the best method of excavating to be applied to it. Borings were made in order to ascertain the extent of the bed of quicksand through which the east and west interceptors must be constructed. This was done by the ordinary artesian well-driving apparatus, 6-inch casing pipe being used and pulled up as soon as the necessary samples had been taken. A number of wash borings were also made by the Engineering Department in connection with its studies on the grade crossing problem. In this way the kind of material to be met in the construction of the interceptors has been ascertained over nearly the entire distance to be traversed.

It was found that the bed of quicksand in the vicinity of Green street extended from Pond street, through Green street, across Franklin street, through Bartlett place and Cherry street, to within about fifty feet of Warren street, and that it extends to great depth, in some places sixty feet of pipe not reaching any other kind of material. Along this route there are a number of brick blocks which would not be more than twelve or fourteen feet from the trench in case of open cut, and it would be very difficult to open cut across the railroad crossing. It should also be observed that Green street is a very busy street with the double tracks of the street railway, over which cars pass once in about three minutes, and there is no parallel street through which this traffic could be conveniently turned.

For these reasons it was decided to construct the interceptor through this section in tunnel, driving the headings with assistance of air pressure.

This method of tunneling was entirely new to the employees of this department, and taking into consideration the danger encountered, not only to buildings in the vicinity, but to the lives of the men working in the tunnel, it was deemed wise to procure the services of a competent man who had had experience in pressure work, to superintend the driving of this tunnel. For this position the department was fortunate in securing Mr. Charles C. Lovejoy, of New York, who has had a long and varied experience in this class of work. Mr. Lovejoy began work March 10, 1899, and finished the 11th of November, the tunnel having been completed with the exception of the final brick lining, which will be put in during the winter.

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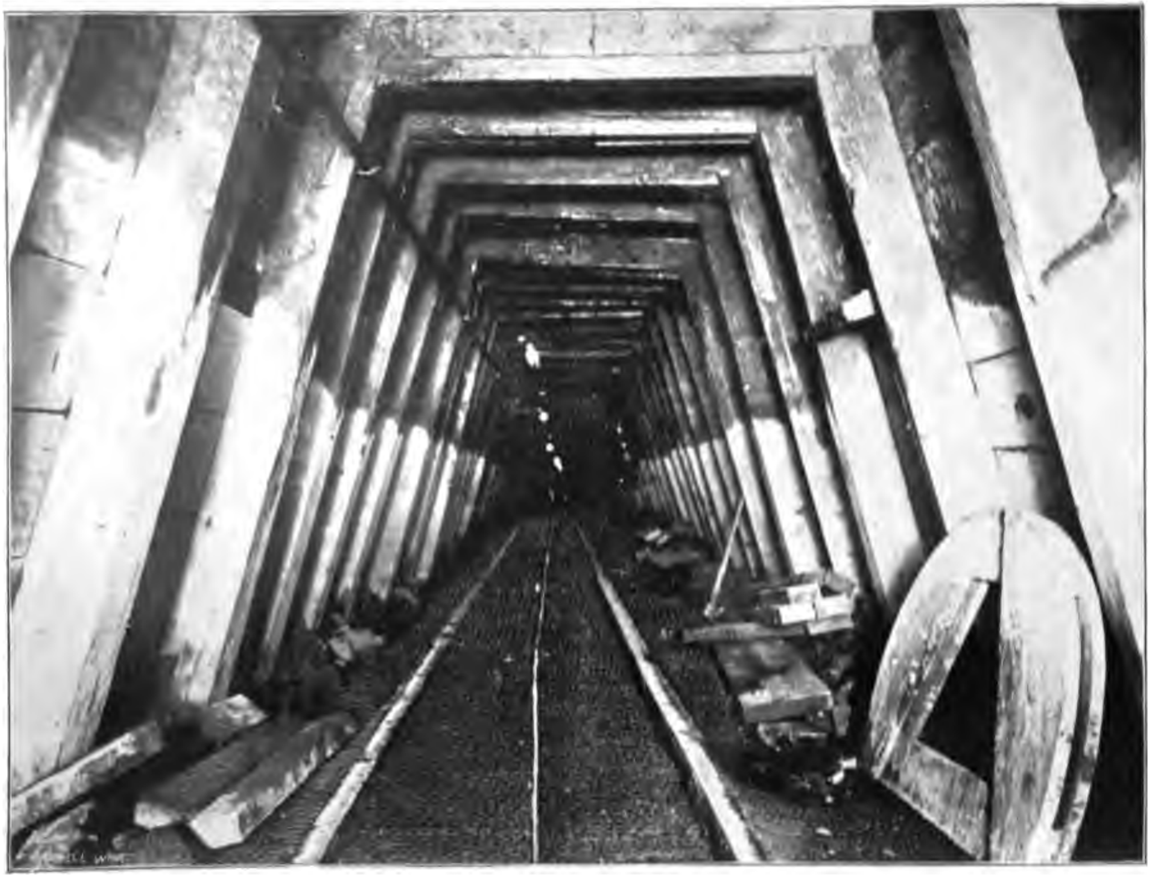


CUT II

CAISSON, AIR-LOCKS AND REGULATING-VALVES.

A caisson was sunk on the line of the tunnel at the corner of Temple and Green streets, which served as a working chamber from which the tunnel drifts were started, and into and out of which all materials were taken through the air-locks. The caisson, which was 8 feet wide, 16 feet long and 7 feet high, was constructed on the surface of the ground and was lowered into position by digging from under the cutting edge from the inside and weighting it down with pig-iron to overcome friction and air pressure. It was built of two thicknesses of 8x8-inch spruce timbers, one course running horizontally and the other vertically. These timbers were securely bolted and drifted together and calked by professional ship calkers. The bottom of the timbers on the sides were cut on a bevel on the inside so as to form a cutting edge. The deck timbers, of same thickness and dimensions as the side timbers, were supported by the sides and also by two trusses, as shown in Figure J. The inside of the entire caisson was mopped with tar after it had been calked. The caisson was lowered until the ground water was reached without the aid of air. Then a slight pressure was applied to drive the water out of the sand, and this was gradually increased until the caisson had reached its proper grade, when the bottom was filled with concrete. Cut K shows working chamber of caisson.

Two air-locks were attached to the deck of the caisson, one for the use of the men, and the other for the passage of stock and dirt excavated.

The bucket-lock was 3 feet in diameter at the top, and 3 feet 4 inches in diameter at the bottom. Sketch J shows a cylindrical lock 3 feet 2 inches in diameter, instead of the tapering lock used. It was 20 feet 10 inches long, and was made of ½-inch boiler plate with butted joints. The heads were of ½-inch plate, stiffened by angle irons. The lower head was hinged at one point on its perimeter, and closed by the attendants by the aid of a rope passing over a shieve.

The upper cover was fastened down by eight hand screws, as shown in the sketch, and was lifted out of position by a link in the hoisting-rope, which passed through a stuffing-box attached to the cover. The cover was in this way carried away from the lock with the bucket, and when the bucket was lowered into the lock the cover was lowered into place, the rope continuing to pass down the lock through the cover. Rubber gaskets were used to make all joints tight. The bucket, as shown in Figure J, held about one-half a cubic yard.

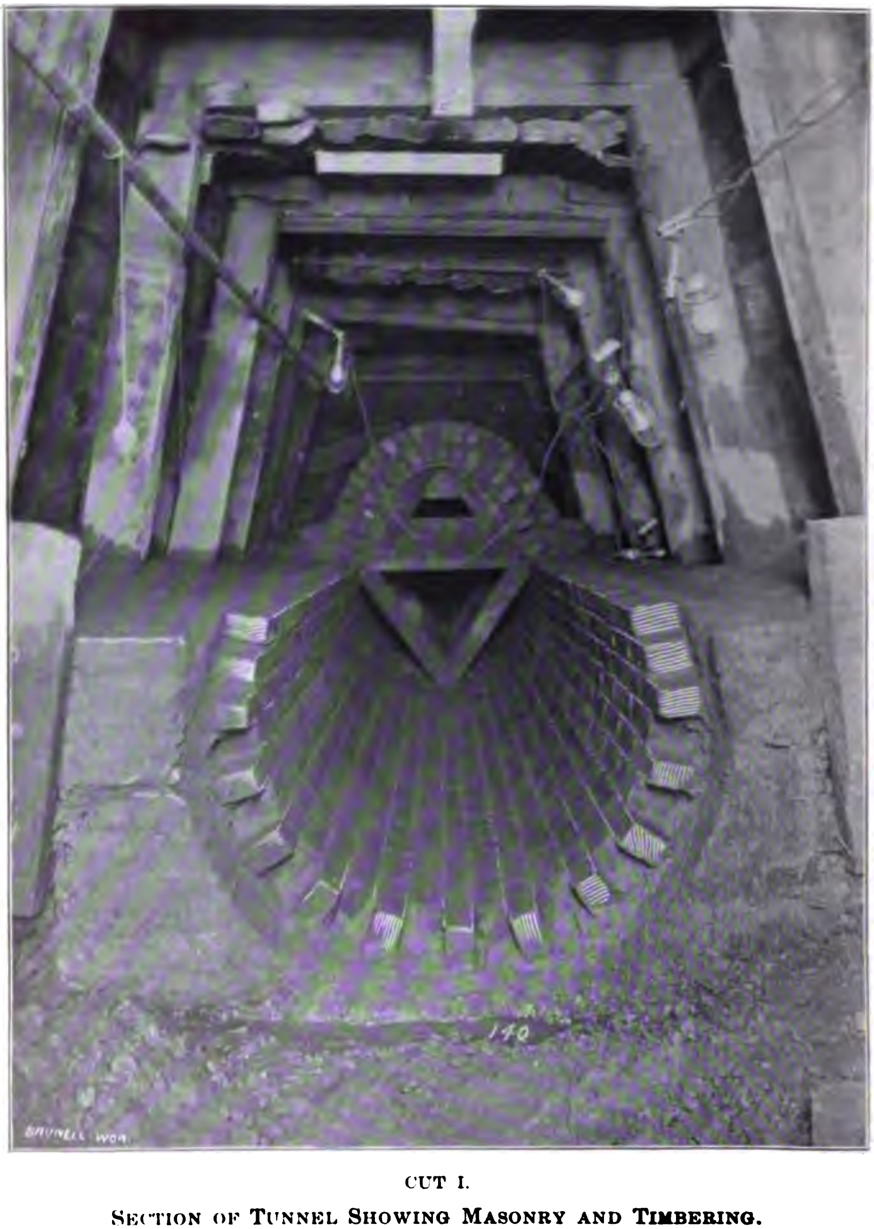
A lock three feet in diameter was provided through which the men entered and left the caisson. This lock was eight and one-half feet in length. It was built of three-eighths inch boiler-plate, with a shaft of the same material extending from the bottom of the lock to the top of the deck, as shown in the accompanying drawing. The top and bottom doors were of three-eighths inch iron, stiffened by angle irons, and faced with rubber gaskets. This lock and the shaft below were provided with iron ladders.

The caisson was provided with a Swedish telephone connecting with the engine-house above and with the power-station on Water street. Compressed air could be admitted through two pipes, although only one was used. A water pipe with hose attached was also provided, as well as suction pipe from pump to remove drainage water.

The compressed air was conducted from the power-station to the regulating valves at the caisson at high pressure. The hoisting-engine operating the buckets was driven by air taken direct from these mains, and the air for the tunnels was passed through two automatic pressure regulating-valves, one four-inch and one three-inch. These valves were made by the d'Estey & Seely Co., of Boston, and governed the pressure perfectly, both when small and large amounts of air were being used.

LINING RINGS.

The temporary lining, put in as fast as material was excavated, consisted of wooden rings eighteen inches long. These rings were cut into eight segments, and as the segments had to be put in place from the inside, one piece was cut so as to form a key, wedging as driven into position from the inside, and the segments each side of it were cut to fit this key. All



CUT I.

SECTION OF TUNNEL SHOWING MASONRY AND TIMBERING.

other pieces were cut on the radial lines. The segments were framed of 2x3-inch North Carolina pine, being pinned together by one-quarter inch carriage bolts. The ribs of the rings were cut on the circle, six feet in diameter on the outside. These segmental frames were covered with ¾-inch matched spruce sheathing, which was stuck curved on one side to rest tightly on the curved frame. The frames were bored by template, so that there was no delay in bolting them together when in place. Three one-half inch bolts were used on each side and two of the same size on each end.

TUNNELING.

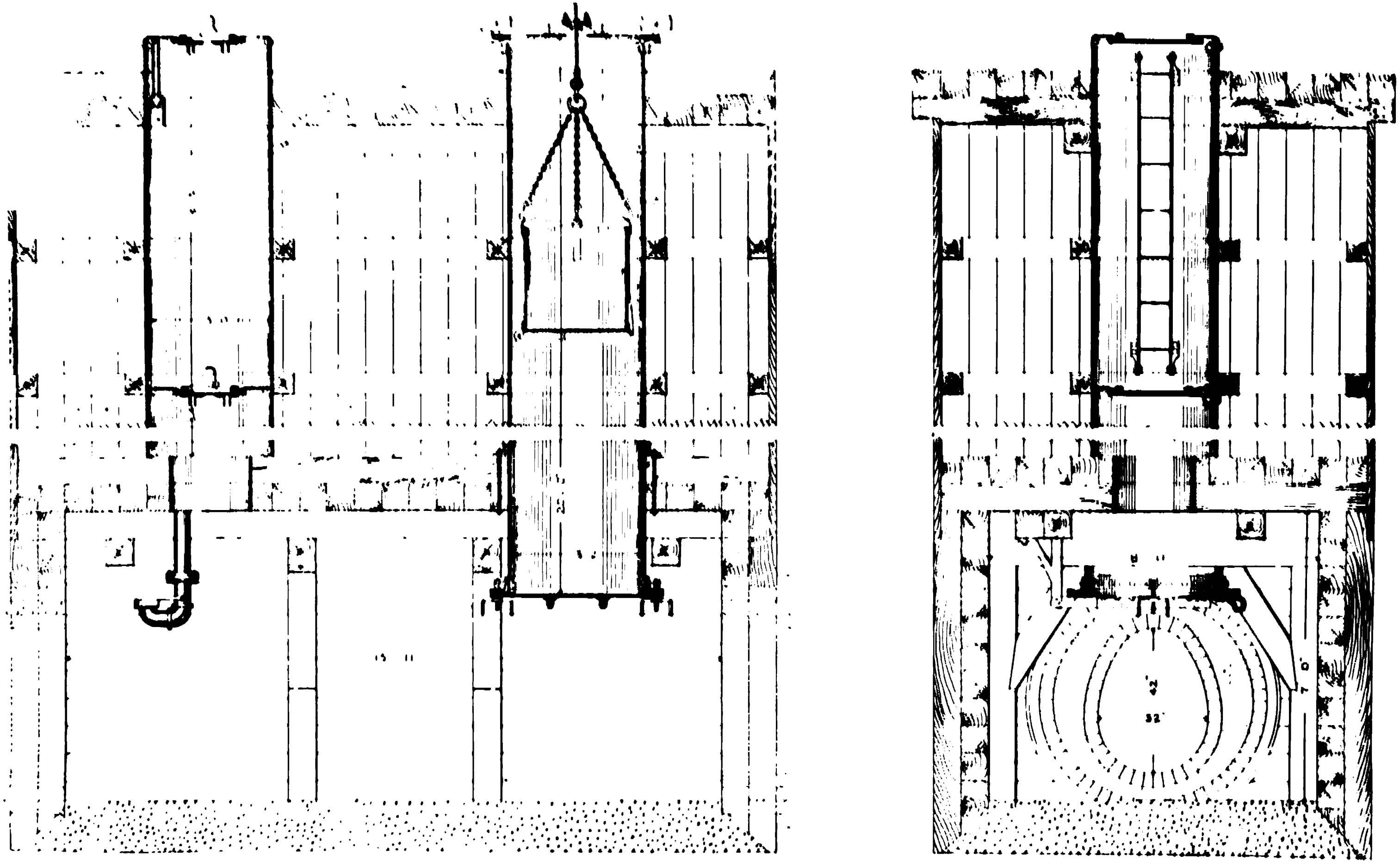
When the caisson was finally in place and the bottom had been put in, openings five and one-half feet in diameter were made in each end, and the first rings bolted to the timbers. As fast as the necessary space was excavated, one section of a ring was quickly put in place and securely bolted to the ring which had just previously been placed. (See Cut L.) In this way the material through which the excavation was made was held in place until the safety lining of brick was put in. It was customary for the safety lining to be built during the first part of one shift, the work being done under the protection of the temporary wooden lining during the balance of that shift and the whole of the one following. In this way from eight to twelve feet of masonry could be laid in each heading in one day.

Much of the time the sand was so loose that it was necessary to work behind the bulkhead, shown in Cut L. This greatly retarded progress, as considerable time was lost in putting in and taking out the bulkheads, which consisted of planks bolted to the rings. It was also necessary to use large quantities of clay to close the cracks in the bulkheads and between the wooden rings.

The section of tunnel under the Green street railroad crossing was protected by iron rings instead of the wooden ones. These were made of one-eighth inch boiler plate, and were pressed into shape when hot. In this way they were flanged and curved at one operation. They were drilled and bolted together in the shop and marked before being taken to the work. The sand through which this section of the tunnel was driven was rather coarse, and the vibrations caused by the rapidly-moving trains above made some trouble at first. The various railroad companies, however, very kindly reduced the speed at which the trains were run and no serious trouble was then experienced.

There were two curved sections in this tunnel. One was a reverse curve, extending from Green street, across Franklin street, into Bartlett place, and the other a very sharp curve from Bartlett place into Cherry street. To follow the proper line in these curves wedge rings were used. These were cut into segments to fit the ordinary rings and were placed between them, the wide portion of the rings being on the outside of the curve. The wedge rings were made of such thickness that with one between every two rings the tunnel was kept on the line of the curve without trouble. In case of deviation from the proper grade the rings were brought back to their proper place by the use of wedge rings, as in the case of the curve in the line. In one case the drift ran so much above grade that it was necessary to lower the bottom before putting in the final lining. This was done by cutting the bottom out of the temporary work in short sections and excavating to the required depth. Each short section was then filled with concrete.

At about 6 o'clock in the evening of August 28 it was discovered that the timbers in the roof of the caisson were burning. After the bulkheads had been hastily secured, an effort was made to force water between the timbers, and put out the fire in this way. This effort was of no avail, however, as long as the air pressure was on; the flames being well fanned, made rapid progress. The air was at once shut off, and an effort made to fight the fire from the caisson, but the smoke drove out the men, two being temporarily overcome by it. The fire was finally extinguished by filling the entire tunnel with water. This took about four hours, and it was several days before tunneling was resumed.



SECTIONS OF CAISSON AND AIR LOCK.

CUT 3

SAFETY LINING.

As has been mentioned, the temporary lining was followed up daily by the construction of the safety lining. This was simply a rim of brickwork consisting of bricks laid flat in the segments of the rings to level up with the ribs, inside of which was laid one course of brick on edge. All masonry was laid in Portland cement. The centres were allowed to remain in place until the cement was hard set, when the tunnel was considered perfectly safe to work in. In fact, the wooden rings were considered safe when the pressure was on, but it was not deemed wise to depend on them when there was no pressure. As fast as the masonry was completed, it was washed with neat Portland cement, to prevent leakage of air. It was also necessary to go over the work frequently and wash sections which had dveloped new leaks. Cut M shows the safety lining as well as the finished work.

FINAL LINING.

After the tunnel was completed, the final lining, bringing it to the required shape, size and grade, remained to be put in. This consisted of an ordinary egg-shaped sewer, 32x42 inches in size, built of one course of brickwork on edge. The space between this and the safety lining was filled with concrete made one part Portland cement, two parts sand and four parts crushed trap rock, pea size. The inside of the sewer was given two coats of neat Portland cement wash, applied with brush. About 300 feet of this lining have been put in, leaving over 1,100 feet to be put in during the coming winter. The detail of this construction can be studied from Cut M.

WEST INTERCEPTOR—SECTION IN COMMERCIAL STREET.

Length, 1,394.9 feet.
Average depth, 16.3 feet.
Size: For 731.5 feet, 24x30 inches; for 663.4 feet, 24 inches.
Estimated cost, $25,510.00.
Cost, $12,242.91.

Work begun, August, 1899.

Work finished, November, 1899.

Foreman, Hugh Montgomery.

The section of the west interceptor between Warren street and Commercial street has not yet been built, but it was desirable for obvious reasons to construct a section in Commercial street before the Street Department worked the street, which had to be done in time to levy the betterment assessment in December, 1899. The digging was very good through most of the street, although large quantities of water had to be pumped. For this purpose a six-inch centrifugal pump was used. For a short distance peat ran below grade. This was removed to hard bottom, and good material filled to grade.

WEST INTERCEPTOR—SECTION IN LAMARTINE, SARGENT, GOLD, BRADLEY STREETS.

Length, 3,529.3 feet.

Sizes, 32x42, 15, 12, 10 and 8 inches.

Estimated cost, $26,764.00.

Cost to date, $18,737.71.

Work begun, June 23, 1899.

Work is unfinished.

Foremen: Robert N. Cundall, Patrick Tracy and Frederick Dearborn.

The district covered by these sewers lies so low that it was impossible to intercept the sewage from any sewers except that in Southbridge street, running north from Sargent street. This sewer was intercepted at the corner of Sargent and Southbridge streets. The rest of the district was resewered, the old system being used for storm water. In order to reach a portion of the district it was necessary to discharge the sewage from it into a collecting chamber at the corner of Gold and Bradley streets, from which the sewage will be pumped into the high-level sewer in Gold street.

A section of about 150 feet in Gold street was laid on piles, as peat extended too far below the grade to be removed, and replaced by good material. A long section in Bradley street is now being piled. If the weather continues good this section will be completed this year.

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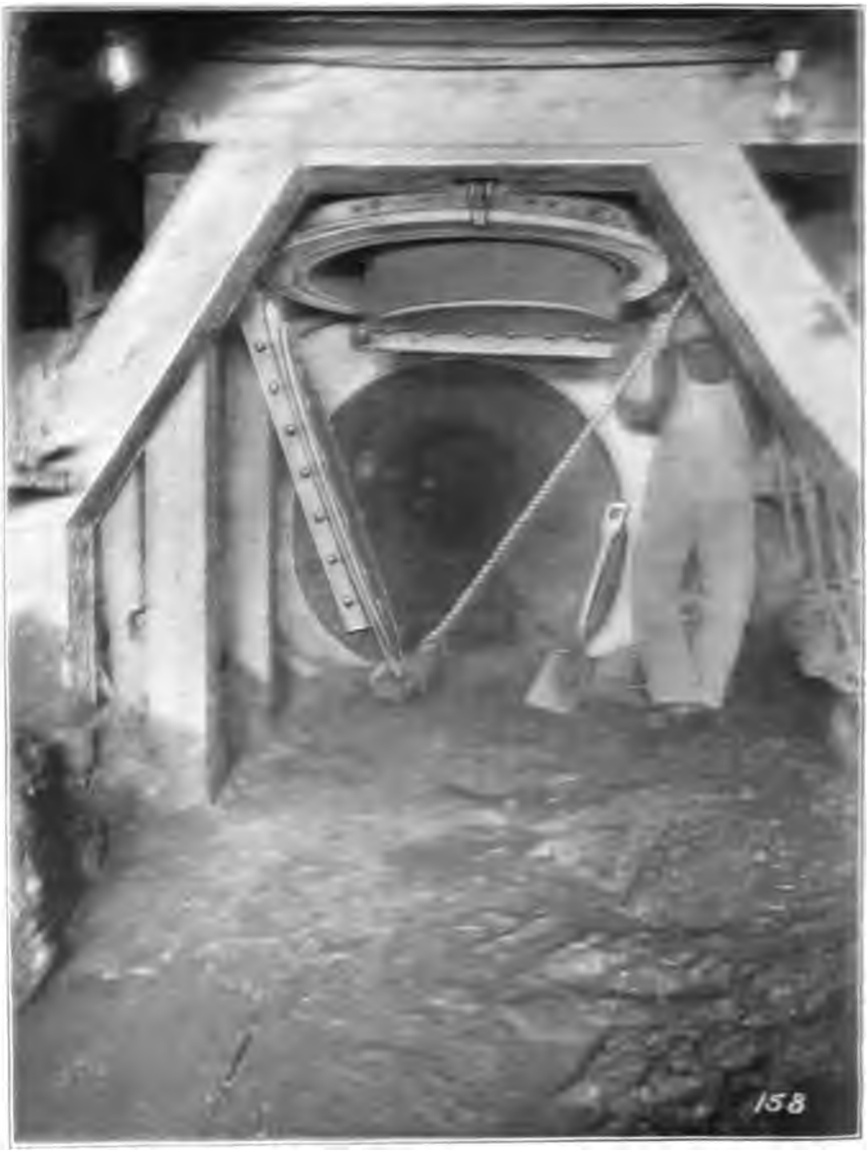

CUT K

WORKING CHAMBER OF CAISSON SHOWING LOCK WITH BUCKET ASCENDING, LOWER DOOR BEING CLOSED.

EAST INTERCEPTOR—SECTION IN MILLBURY STREET, FROM CAMBRIDGE STREET TO VERNON SQUARE.

Length, 3,478 feet.

Average depth, 16.6 feet.

Size: For 2,758.8 feet, 48 inches round; for 717.2 feet, 32x42 inches.

Estimated cost, $38,700.00.

Cost, $33,604.34.

Work begun, July, 1898.

Work finished, June, 1899.

Foreman, Hugh Montgomery.

This sewer starts from the chamber at the east end of the east syphons and extends through Millbury street to Vernon square, where it connects with the section laid in tunnel through Water street. The excavation was through hardpan almost the entire distance. A small amount of rock had to be removed, but this did not very materially retard the work. A small flow of water was encountered, which was readily disposed of by hand pumping.

It was necessary to close the north-bound street railway track because of the narrowness of the street. By the use of cross-overs the cars passed the work on the south-bound track, and were not materially delayed.

Several of the regulators, through which the sewage of the old system of sewers will be admitted to the interceptor, have been constructed, and it is expected to have them all completed before winter sets in.

POWER-STATION, WATER STREET.

Engineer in charge of mechanical engineering, Harry L. Dadmun.

Engineer in charge of electrical engineering, Robert N. Cundall.

Engineer in charge of station, day shift, M. Osmer Scott.

Engineer in charge of station, night shift, Frank A. Grimley.

The pneumatic tunnel through the quicksands of Green street required large quantities of compressed air, and in the Water street tunnels the drills were driven by the same power, All the tunnels were lighted by electricity, and electric motor-cars were operated in several. The necessary station for furnishing this power was established at the corner of Water and Pond streets. A section of the building belonging to the F. B. Norton heirs and formerly used for manufacturing pottery was leased for this purpose.

With the complete equipment of boilers and machinery, the station was very crowded, although it served its purpose. The ventilation was very poor, much of the time the temperature of the engine-room being from 120 to 135 degrees Fahrenheit. A 24-inch Berry ventilating fan was put in to secure better ventilation, but it was able to reduce the temperature only ten or fifteen degrees.

Three horizontal, fire-tube boilers were installed. They were obtained from different concerns, and were second-hand boilers. but were accepted only on certificate of the Hartford Steam Boiler Inspection & Insurance Co., in which they are insured. Each boiler was 6 feet in diameter and from 15 to 16 feet in length, and developed under ordinary conditions 125 H. P., thus affording a combined output of 375 H. P. These boilers were connected with a steel stack 3 feet in diameter and 80 feet high.

The electric current was generated by the dynamo used in connection with the construction of the conduit in Millbrook, and a new Holtzer-Cabot generator of the same capacity and potential. These machines were driven by a 12x34 inch Brown engine, devoloping 60 H. P. at 70 revolutions per minute. This engine had been owned by the department for a number of years, and performed its work very satisfactorily.

The switch-board was an inexpensive skeleton affair, and was so wired that either machine could carry the load of either the Green street tunnel or the Water street tunnel, and by overloading either machine it was possible to shut the other down for repairs at times when the load was not unusually heavy. From the switch-board, lines were run to Green street and Water street. From these main lines, branches were run to each shaft where fuse blocks and switches were placed, and from them lines were run into the tunnels. Thus, it was possible to shut off the current from any tunnel without interfering with the light or power of the others. The switch-board was

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system were the liability to frequent short circuits, caused by dropping of tools across the rails, and difficulty of insulation. The former did not trouble often enough to be a serious inconvenience, and when a short circuit did occur it was a matter of but a few seconds before the engineer in the power-station could throw in the circuit-breaker. The method of insulation adopted proved quite satisfactory, and the leakage was unimportant.

The motor-cars consisted of inexpensive trucks equipped with General Electric Co. motors, type C. E., wound for 220 volts, and developing 5 H. P., railway rating. A sprocket-wheel was used in place of the customary driving-pulley, and was connected to one axle of the car by chain and larger sprocket-wheel. A speed of six miles an hour was easily obtained when drawing a loaded stock-car. The inconvenience caused the men by touching or stepping on the live rail was very slight, and the voltage proved satisfactory in every respect.

Care was always taken to shut off light and power currents when blasting materials were being placed in position for service, because of the possibility, though generally quite remote, of the wires of the fuses becoming connected with the rails or light-wires. The result, if such a circuit should be formed, would probably be disastrous.

Compressed Air.

All hoisting-engines and pumps working at the tunnel shafts were operated by compressed air, as well as the rock-drills in the Water street tunnel. At times, as many as six No. 3 B drills were in use. The tunnel in Green street, which was driven under pressure, was not started until most of the work in the rock tunnels was finished. The compressor-plant would not have been of sufficient capacity to have supplied air for all tunnels at the same time.

Two air compressors were installed to meet these requirements. One was a Class B, 10x16 inches, duplex machine, made by the Rand Drill Co., and owned by the department for the last twelve or fifteen years. This machine required a boiler capacity of about 45 H. P. at 100 revolutions. At this speed

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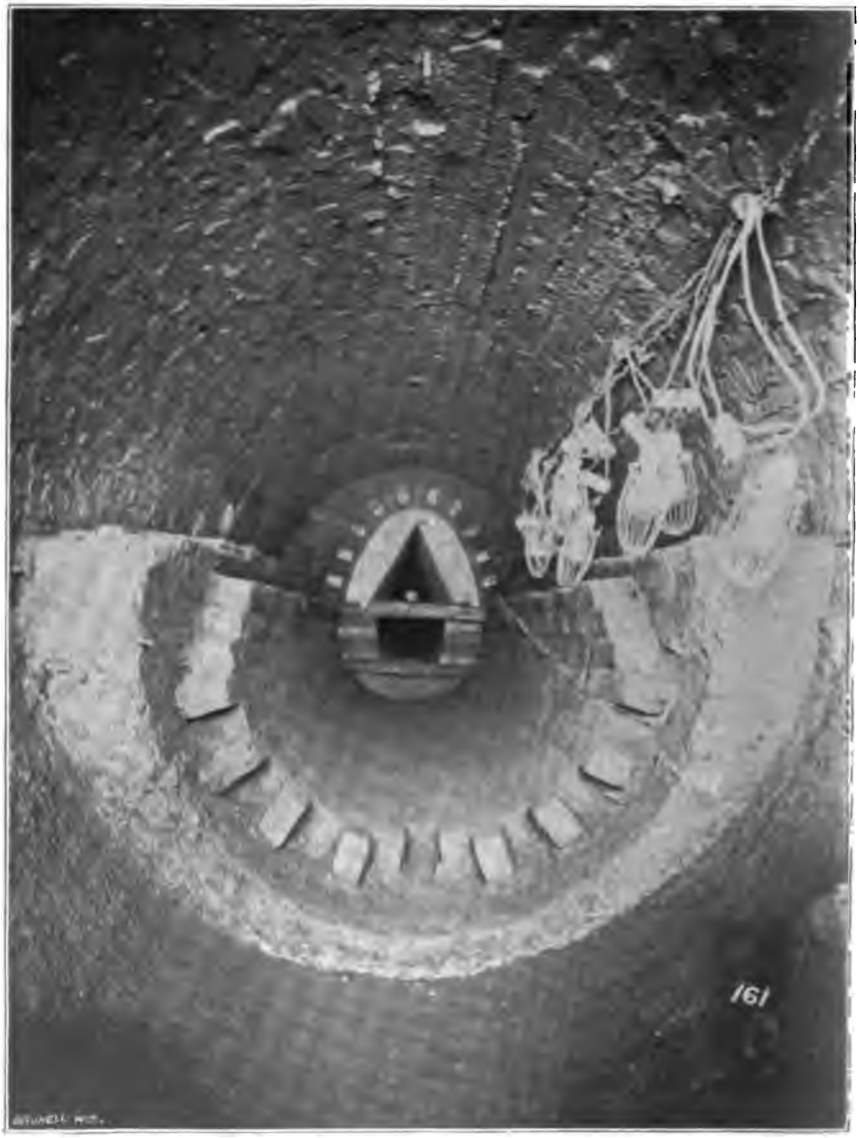


CUT M.

SECTION OF PNEUMATIC TUNNEL SHOWING SAFETY LINING AND FINISHED SEWER, WITH CONCRETE BETWEEN THE TWO.

it was capable of compressing about 290 cubic feet of free air per minute to 80 pounds pressure, at which pressure the air would occupy a space of about 45 cubic feet. The other was a second-hand Class B, 14x22 inches, duplex compressor, made by the same firm, and bought especially for this work. This machine, running at 85 revolutions per minute, compressed 666 cubic feet of free air to 104 cubic feet at a pressure of 80 pounds, and required a boiler capacity of 110 H. P. During the most difficult portion of the pneumatic tunnel both machines greatly exceeded this output, the smaller running at about 130 revolutions, and furnishing 86 cubic feet of air at about 50 pounds pressure, while the larger compressor was running at about 95 revolutions, and furnished 169 cubic feet of air at the same pressure.

The tunnels in Water street were supplied with the necessary air by a three-inch main laid under the sidewalk. The Green street tunnels were supplied by two lines, one three-inch and one four-inch. At the corner of Green and Winter streets, a pressure-equalizing tank, 5x14 feet, was connected with the air-line. All mains were connected with the pressure-equalizing tank at the power-house, which was so piped that either or both compressors could supply one or all lines through it or without it. This tank was 12 feet long and 5 feet in diameter.

EAST INTERCEPTOR—SECTION IN VERNON SQUARE AND WATER STREET.

Length, 1,446 feet.

Average depth, 22 feet.

Size, 40x54 inches.

Estimated cost, $79,000.00 (complete from Millbury street to Grafton street).

Cost, $47,634.99.

Work begun, December, 1898.

Work finished, October, 1899.

Engineer in charge of electrical engineering, Robert N. Cundall.

Foremen: On day shift: Patrick Fox, John McGrath and

TABLE XIV.

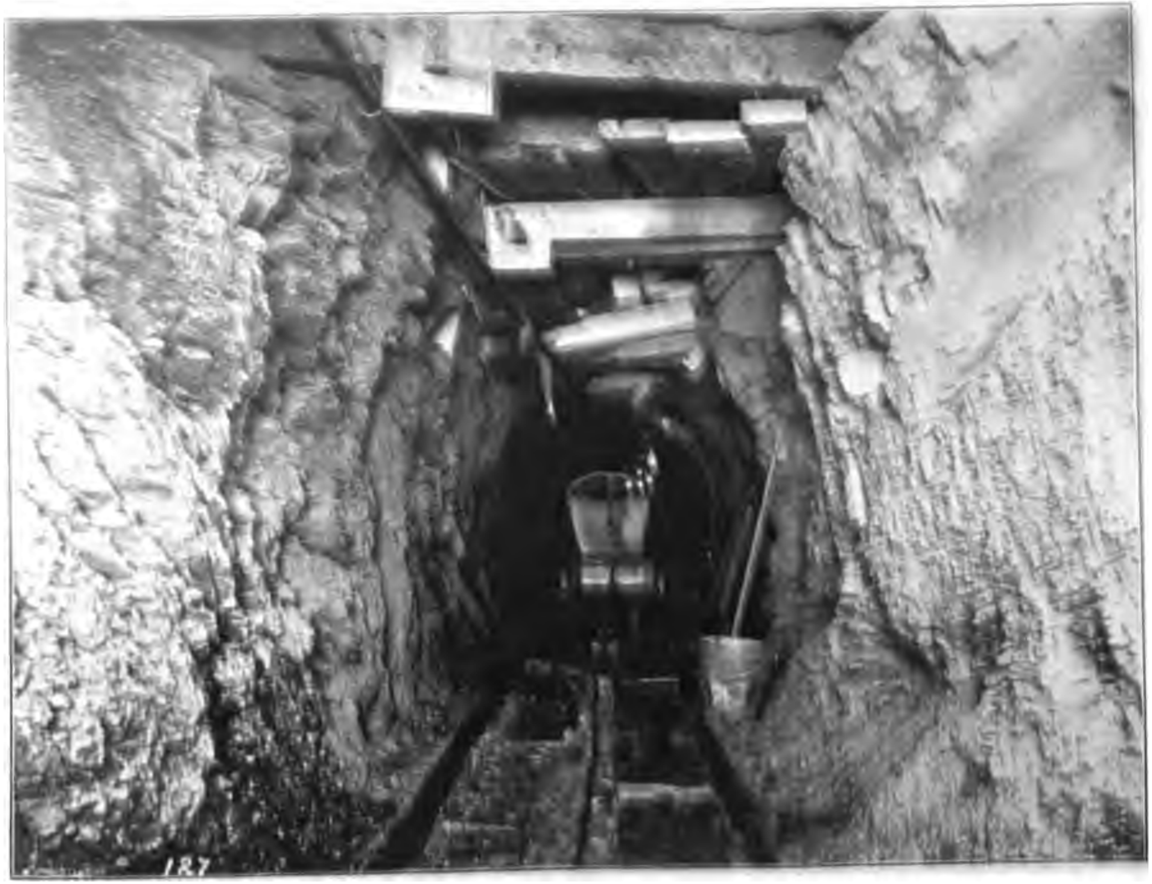
RESULTS OF THE CHEMICAL PRECIPITATION OF THE SEWAGE.

Monthly Averages of Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals.
	Free.	ALBUMINOID.						
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.		
Sewage, December, 1898,	.669	.314	.145	.169	3.61	2.02	3.48	16.4
Effluent, " "	.583	.172	.157	.015	1.86	1.86	3.58	
Per cent. removed,	12.85	43.95	-7.65	91.11	48.48	8.60	-2.85	
Sewage, January, 1899,	.593	.281	.158	.123	3.30	1.95	3.66	18.0
Effluent, " "	.539	.152	.143	.009	1.88	1.88	3.43	
Per cent. removed,	9.10	45.91	9.49	92.68	43.08	3.59	6.28	
Sewage, February, 1899,	.716	.353	.193	.160	4.18	2.51	4.41	17.6
Effluent, " "	.645	.190	.181	.009	2.26	2.26	4.38	
Per cent. removed,	9.92	46.17	6.22	94.39	45.93	9.96	0.68	
Sewage, March, 1899,	.450	.266	.141	.125	3.32	2.02	2.99	15.4
Effluent, " "	.405	.147	.138	.009	1.74	1.74	2.95	
Per cent. removed,	10.00	44.73	2.13	92.81	44.59	13.87	1.33	
Sewage, April, 1899,	.519	.266	.146	.220	3.33	1.69	3.69	18.4
Effluent, " "	.451	.139	.132	.007	1.55	1.55	3.60	
Per cent. removed,	13.10	47.74	9.58	94.17	53.46	8.28	2.44	
Sewage, May, 1899,	1.234	.577	.323	.254	6.09	3.22	5.36	17.0
Effluent, " "	1.106	.266	.256	.011	2.92	2.92	5.47	
Per cent. removed,	10.37	53.91	21.05	95.68	52.06	9.32	-1.70	
Sewage, June, 1899,	1.302	.616	.264	.352	6.53	3.37	7.60	16.8
Effluent, " "	1.145	.276	.260	.016	3.07	3.07	7.70	
Per cent. removed,	12.14	55.20	1.58	95.45	52.99	8.90	-1.32	
Sewage, July, 1899,	1.469	.640	.287	.353	6.47	3.29	8.06	15.3
Effluent, " "	1.356	.281	.269	.012	3.35	3.35	.35	
Per cent. removed,	7.69	56.10	6.27	96.61	48.22	-1.82	-0.37	
Sewage, August, 1899,	1.373	.612	.278	.334	6.76	3.71	7.91	16.8
Effluent, " "	1.231	.254	.240	.014	3.24	3.24	8.14	
Per cent. removed,	10.31	58.82	13.68	95.81	52.08	12.67	-2.91	
Sewage, September, 1899,	1.344	.584	.324	.260	7.31	4.27	7.10	17.3
Effluent, " "	1.240	.257	.244	.013	3.25	3.25	7.20	
Per cent. removed,	7.74	60.00	24.69	94.99	55.54	23.89	-1.41	
Sewage, October, 1899,	1.777	.652	.315	.337	8.23	4.96	8.01	16.9
Effluent, " "	1.589	.277	.269	.008	3.71	3.71	8.08	
Per cent. removed,	10.45	57.51	14.61	97.63	54.92	25.20	-0.87	
Sewage, November, 1899,	1.702	.593	.280	.313	8.29	5.49	7.52	15.9
Effluent, " "	1.547	.253	.246	.007	3.77	3.77	8.00	
Per cent. removed,	9.11	57.33	12.14	97.77	54.51	31.25	-6.38	
Sewage for year ending Dec. 1, 1899,	1.097	.480	.237	.243	5.63	3.24	5.87	17.1
Effluent " " " " " "	.988	.222	.211	.011	2.71	2.71	6.00	
Per cent. removed,	9.93	53.73	10.97	95.53	51.73	16.36	-2.23	

NOTE.—Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of the sampling. Effluent samples consist of twenty-four portions taken hourly.



CUT N.

SECTION OF TUNNEL IN WATER STREET SHOWING ROOF BRACING, COMPRESSED AIR PIPE AND CAR TRACK, WITH THIRD RAIL IN PLACE.

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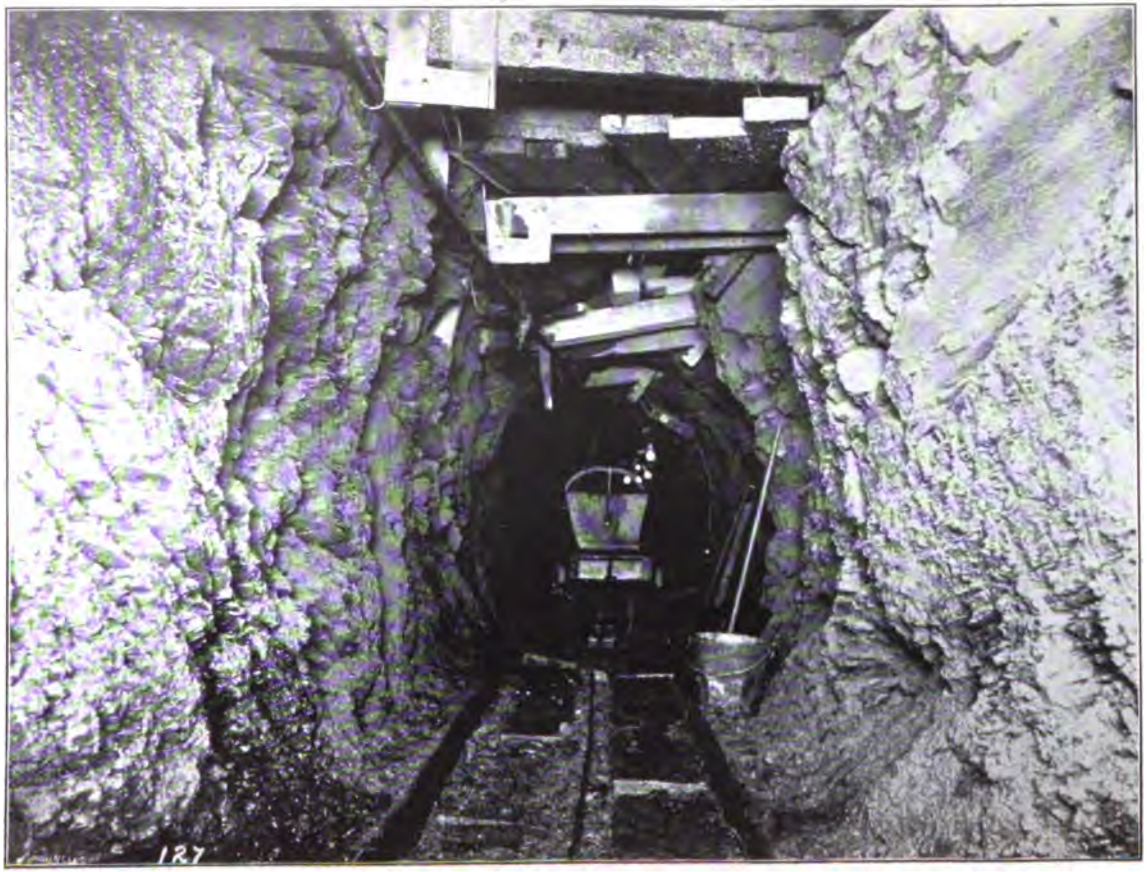


CUT N.

SECTION OF TUNNEL IN WATER STREET SHOWING ROOF BRACING, COMPRESSED AIR PIPE AND CAR TRACK, WITH THIRD RAIL IN PLACE.

All of this work, as well as that beyond in Washburn, Southbridge, Southgate, Hammond and Canterbury streets, was necessitated by the high level at which the sewage from this section had to be taken into the Millbrook conduit. The question of grade was the complicating feature of this section.

The level of Cambridge street, under the bridge of the New York, New Haven & Hartford Railroad Co., is but a few feet above the bottom of Millbrook, and on this account the seven-foot sewer built in 1882 and 1883 was constructed in the sidewalk, and the walk raised about four feet above the roadway to ensure proper covering.

The new sewer, which was required to take the place of this one, had to be built at a higher grade, and there was neither sufficient depth in the street under the bridge, nor sufficient grade to allow of siphoning under the old sewer, which would have to be crossed before the collecting-chamber could be reached. Accordingly, a section of the old sewer between Garfield street and Kansas street was abandoned to the new system. A new invert of the required size was constructed through this sewer, and then leaving the old sewer the new one was extended to the collecting-chamber on the east and to Washburn street on the west.

The new surface-water conduit is of rectangular shape, with curved corners in the invert, and was built through the street and connected with the old seven-foot sewer at Kansas and Garfield sreets. This sewer was built of Portland cement concrete. See Cut P. The narrowest section was seven feet nine inches wide, and the roof was twelve inches thick. This section was widened to eight feet six inches under the bridge. Three-inch No. 10 expanded metal was placed in the roof four inches up from its under side. Where there was insufficient covering, I-beams were placed in the roof four feet apart, with the expanded metal between them. These methods of construction are illustrated in Cuts Q and R.

The excavating for the drain was in quicksand, but no damage was done to adjacent buildings, although the greatest care was necessary to prevent movement of material outside the trench.

While the new invert was being built, the sewage was diverted through the surface-water drain which had previously been connected with the old sewer. Pumping was only necessary to take care of the house-connections entering this section.

SOUTH INTERCEPTOR—SECTIONS IN WASHBURN, SOUTHBRIDGE, SOUTHGATE, HAMMOND AND CANTERBURY STREETS.

Length, 4,977.1 feet.
Sizes: 24x36, 20, 18, 15, 12, 10 and 8 inches.
Estimated cost, $41,360.00.
Cost, $22,634.28.
Work begun, June 23, 1899.
Work finished December 1, 1899.
Foreman, Patrick Fox.

The sewer in Washburn street was so low that its flow could not be intercepted by the new sewer in Cambridge street. Consequently, the old sewer was abandoned to use as a surface-water drain, and a new line run through Washburn, Southbridge and Southgate streets to the tracks of the New England R. R., where the difference in grade between the two sewers was sufficient for interception.

The new sewer was continued through Southbridge, Hammond and Canterbury streets completing the duplicate system in this district. It was impossible to intercept because of lack of grade. In Southbridge street the old and new sewers were so nearly on a level that it was impossible to carry the house-drains on the east side of the street either under or over the old sewer to connect with the new one. To intercept these particular drains an eight-inch sewer was laid a distance of about 500 feet north from the main sewer at Southgate street where the connection could be made. This pipe was laid through the sidewalk to avoid disturbing the block paving recently laid on a concrete base on the east side of the street.

This section of the separating system, comprising nearly a mile of new work, was not complicated by any serious difficulties of construction. As usual, some ground water was encountered, but it was easily taken care of by sub-drainage and pumping. A six-inch centrifugal pump was stationed at Cambridge street, and for a time was kept running nearly continuously. Later, the drain was stopped so that the water would not flow back through it into the trench, and a three-inch pulsometer, kept ahead of the work, replaced the six-inch pump.

SEPARATION OF SURFACE-WATER FROM SEWAGE IN THE SOUTHERN AND WESTERN PORTIONS OF THE CITY.

The area of the Millbrook sewer between Cambridge street and the Blackstone river has been very materially reduced by the construction of the new sewage conduit. At present both ends of this conduit are opened so that the reduction in area is equal only to the area of the masonry section. When, however, the connections are made with the collecting-chamber at Cambridge street and with the outfall sewer at Quinsigamond Village, the area of the entire conduit will be taken from the effective section of Millbrook. This will cause a serious reduction in the capacity of the large sewer, which, at times, has been taxed to its utmost to carry off the water delivered to it. This condition makes it absolutely necessary to divert a portion of the storm-water which would naturally find its way to this sewer. Accordingly, it was decided to put in a storm-water system of drains in the southern and western parts of the city to collect and discharge into adjacent streams a sufficient amount of storm-water to offset the displacement of this conduit.

Work in these sections was begun in 1897, and has been continued to date with the result that about 75 per cent. of the work is done.

In some streets the old sewers are kept for sewage and new surface drains are built, and in other cases the reverse is true. The general policy is, however, to build new sewers, as the old ones are of ample capacity for the surface water, and it is important that the newest and best work be kept for sewage.

The total estimate for this work was $178,210.00, of which $112,473.36 has been expended.

PURIFICATION.

The purification of the sewage is and probably always will be, the part of the work allotted to this department which is of most popular interest. This is due mainly to the large appropriations which are necessary to the successful solution of this problem.

From time to time reports have been printed explaining this work and setting forth the necessities for further constructions of various kinds. During the past year, at the request of the City Council a special report was printed giving a "Résumé of the Studies and Progress made toward the Solution of the Sewerage Problem." All of these reports are available to the citizens, and would doubtless answer many questions arising in their minds if copies were obtained for reference.

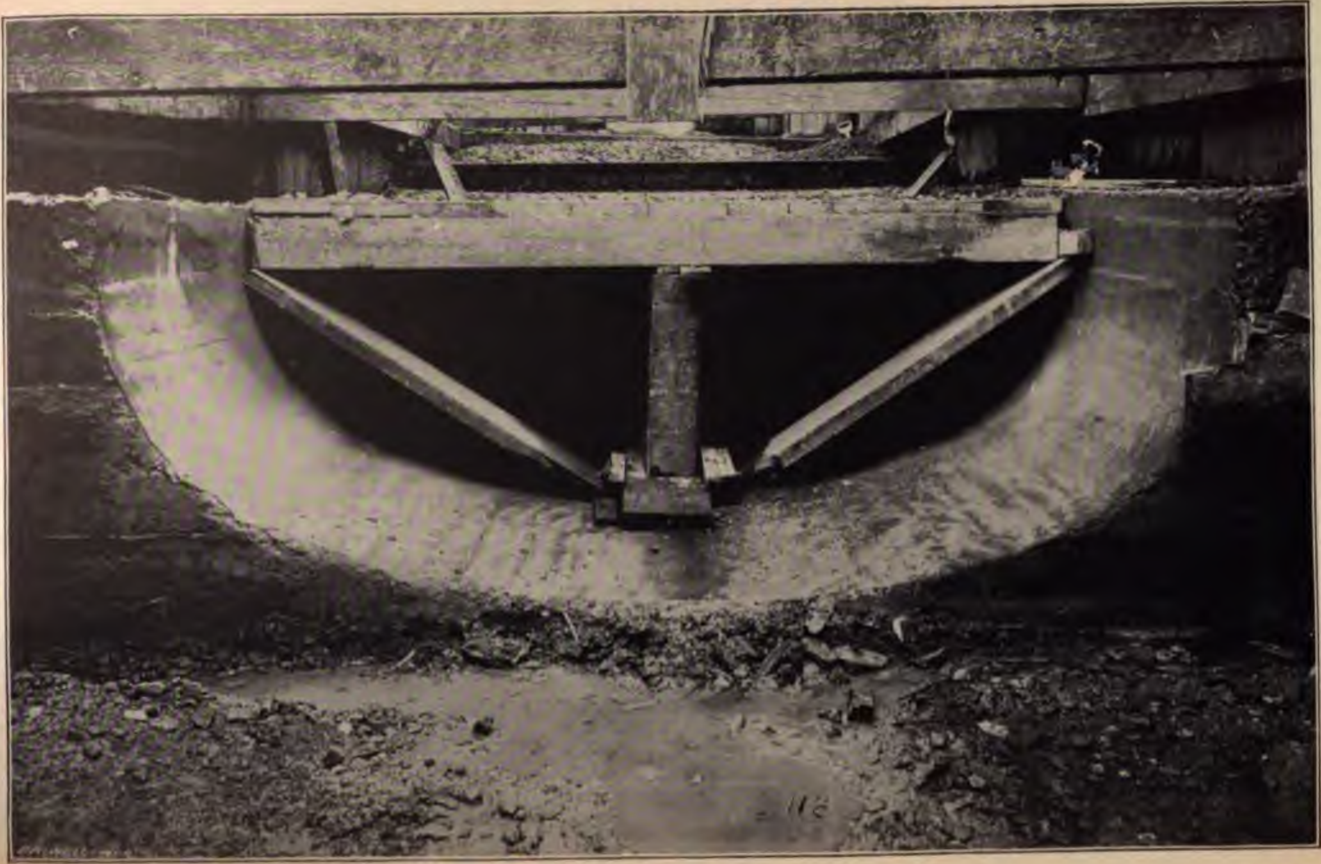
The average amount of sewage treated daily has been [illegible] million gallons. As in former years, some sewage has been discharged into the Blackstone river during storms. The average amount of water entering the Mill brook sewer from Salisbury pond has been [illegible] million gallons daily. This is comparatively clean water, and as has often been stated, greatly complicates the problem of treatment. This flow was not uniform throughout the year. From December 1, [illegible], to May 1, [illegible], the average daily flow was [illegible] million gallons, which amounted to an average of [illegible] million gallons daily from May 1, [illegible], to December 1, [illegible]. During this latter period the flow of sewage at the outlet has been [illegible] million gallons, of which 6.0 million gallons was clean pond water from Salisbury pond, leaving 10.6 million gallons of sewage proper. From a study of these figures it will be seen that the early construction of the intercepting sewers is of much importance.

CHEMICAL PRECIPITATION.

The chemical treatment of the sewage has been continued throughout the past year, and all the sewage which could be forced through the outfall sewer has been treated, either by this method or by intermittent filtration. The method of treatment has remained practically unchanged, and the results have been about the same as in former years.

[illegible]

[illegible] Surface Water Conduit in Cambridge Street. The Timbering is in Place



CUT P.

Street. The Timbering is in Place

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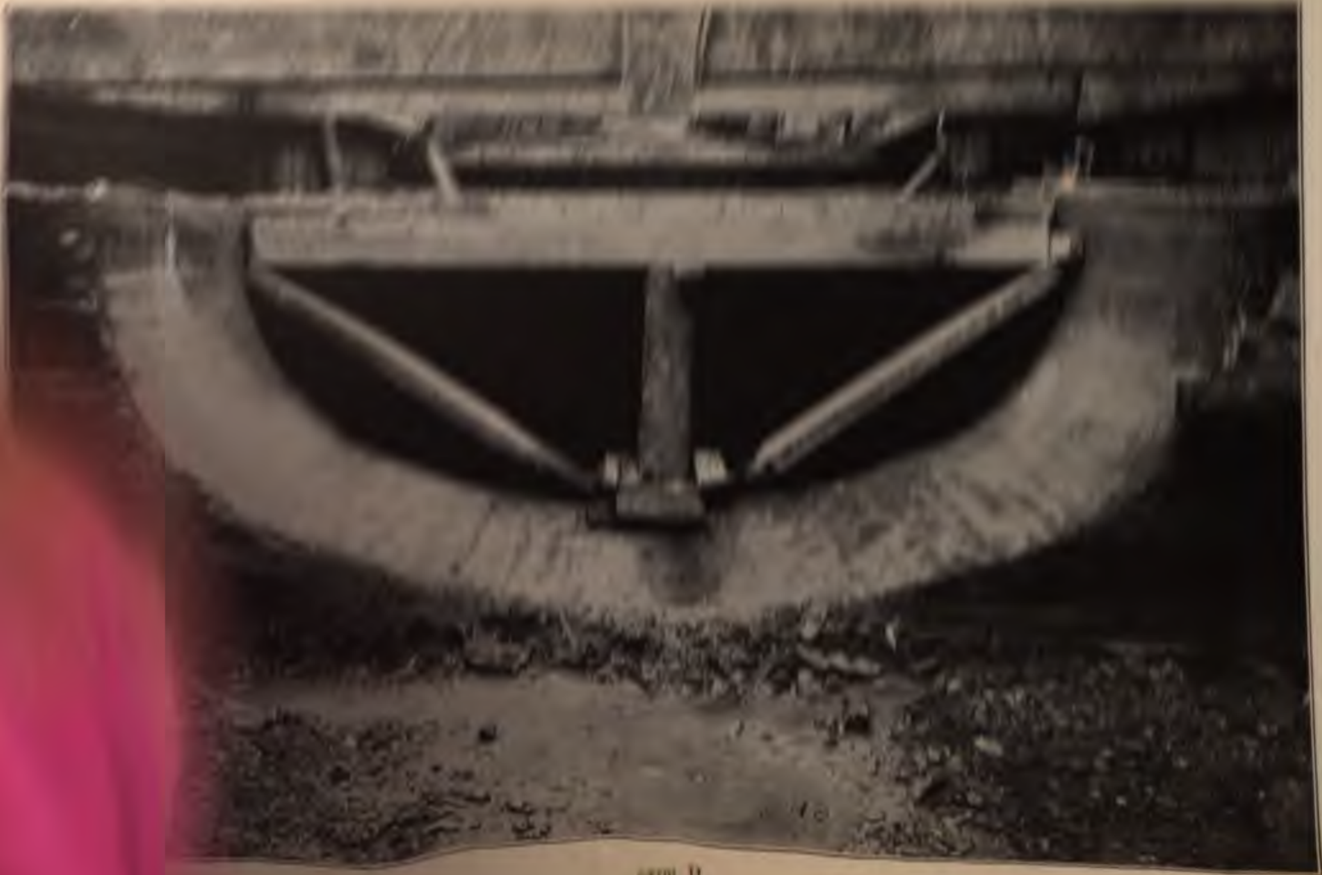


CUT P.

of Concrete Surface Water Conduit in Cambridge Street. The Timbering *is in* Place to Receive Concrete Roof.

Per. Cent. Organic Matter Removed from Sewage.

DESCRIPTION.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Total amount (by evaporation),	50.88	49.35	...	..	—	—	
Amount in suspension (by evaporation),	90.67	94.45	- -	- -	- -	— -	
Total amount (by albuminoid ammonia),	48.49	50.79	51.63	53.92	54.02	51.82	53.73
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11	92 02	93.46	92.62	95.53
Total amount (by oxygen consumed),	33 65	43.84	54.35	51.02	52.00	48 89	51.73
Amount in suspension (by oxygen consumed),	80.85	81.08	78.01	—	—	—	—

NOTE. Although the determination of oxygen consumed has been made throughout the year, it is not considered as reliable as the determinations of albuminoid ammonia, because of large amounts of iron present in the sewage, and also because the determinations for oxygen consumed are by no means as satisfactory as those for albuminoid ammonia.

TABLE XVI.

Per Cent. Organic Matter Removed from Sewage by Seasons.

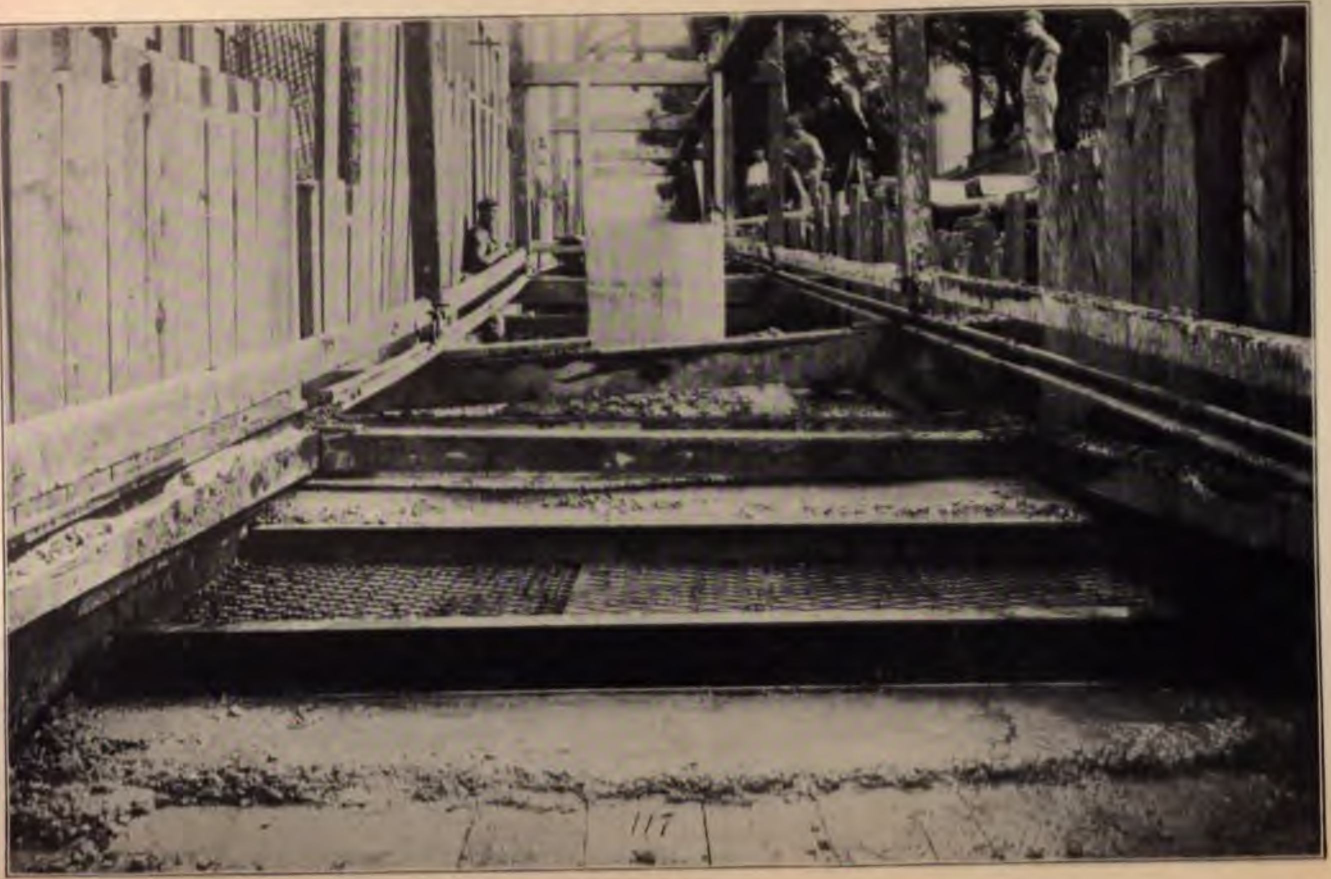
DESCRIPTION.	DECEMBER TO JULY.						JULY TO DECEMBER.						
	1894.	1895.	1896.	1897.	1898.	1899.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
Total amount (by evaporation),	42.76	—	—	—	—	—	50.88	55.02	—	—	—	—	—
Amount in suspension (by evaporation),	93.08	—	—	—	—	—	90.67	95.76	—	—	—	—	—
Total amount (by albuminoid ammonia),	46.63	49.69	52.00	48.91	48.67	49.81	48.49	53.78	52.93	56.10	57.14	54.86	57.06
Amount in suspension (by albuminoid ammonia),	83.26	91.73	91 45	92.19	93.55	94.16	76.67	94.36	90.75	93.35	94.30	91.58	96.56
Total amount (by oxygen consumed),	37.11	46.92	50.78	48.84	46.20	49 85	33.65	50.23	61.08	53.15	55.46	50.84	53.31
Amount in suspension (by oxygen consumed),	89.27	82.95	—	—	—	—	80.85	92.42	72.91	—	—	—	-

James Mulhern; on night shift: Timothy Connor, Patrick Tracy and Thomas Mulhern.

No borings had been made along the line of this sewer, but from what excavating had been done in the vicinity it was supposed that rock would be reached but a few feet below the surface of the street, and that the drifts would be entirely in ledge. For this reason and on account of the car-track, the heavy traffic of the street and the pavements, which consisted of granite blocks laid on cement concrete base and grouted with Portland cement, it seemed advisable to construct this sewer in tunnel. Accordingly three shafts were sunk, one 8 feet by 10 feet at Fox street, and one each at Harrison street and Pond street, which were 8 feet wide by 16 feet long.

From these shafts drifts were started in each direction, and when the tunnel was finished it extended from Millbury street to Ledge street continuously, a distance of about 1,400 feet.

The material through which the different sections of tunnel were driven varied greatly, and did not always turn out as previously expected. The excavation from the Fox street shaft was almost wholly through ledge, although frequently hardpan appeared in the roof, which required bracing in such cases, as shown in Cut N. The widest variation in material existed in the Harrison street section. The south drift ran for a considerable distance through a combination of ledge and hardpan. This required very careful bracing and sheathing, which caused great delay. It generally took the entire time of the night force to put in the timbering and to remove the dirt. The day-shift did the drilling and blasting. The north drift ran through a pocket of gravel, which was very loose and required extreme care to prevent it from running from overhead. For a short distance this material was so extremely loose that it became necessary to work behind a bulkhead, removing the plank and placing it ahead as the work progressed, working from the roof down. This drift ran from the entire heading in gravel to part rock and part gravel, and then to an entire face of rock. The Pond street drifts started in rock, and no dirt appeared in the south heading. The north heading ran into hardpan and gravel, with indications at the point



CUT R.

SECTION OF SURFACE WATER CONDUIT IN CAMBRIDGE STREET SHOWING I-BEAMS, EXPANDED METAL, AND CONCRETE ROOF.

TABLE XVII.

RESULTS OF CHEMICAL PRECIPITATION AND FILTRATION OF THE SEWAGE.

MONTHLY AVERAGES OF ANALYSES OF SEWAGE AND EFFLUENT.

(Parts per 100,000.)

METHOD.	DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		CHLORINE.	At Rate Per Day in Mil. Gals.
		Free.	Albuminoid.			Unfiltered.	Filtered.		
			Total.	Dissolved.	Suspended.				
Chemical treatment.......	Sewage, October, 1899 ..	1.777	.652	.315	.337	9 53	4 06	8.01	13 1
	Effluent, " " .	1 590	.277	.269	.008	3 71	3 71	8.08	
	Per cent. removed. .	10 45	57 51	14 61	97.68	61.03	35 30	0 87	
Filter-beds....	Sewage, October, 1899.....	1 391	.375	.188	.187	5 83	3 01	8 33	4 8
	Effluent, " " .	1 379	.033	.033	.000	1 36	1 36	8 33	
	Per cent removed. .	0.74	91.20	82 40	100 00	76 80	55 70	0 00	
Average of both methods..	Sewage, October, 1899 ...	1 609	.673	.278	.394	7 54	4 37	7 60	16 9
	Effluent, " " ..	1.500	.307	.301	.006	3 07	3 07	7 55	
	Per cent. removed	6.77	53.81	37 70	97 97	59 28	29 75	0 67	
Chemical treatment .. .	Sewage, November, 1899..	1 702	.593	.280	.318	8 90	5 40	7 53	11.9
	Effluent, " " ..	1 547	.253	.246	.007	3 47	3 77	8.00	
	Per cent. removed ...	9 11	57 33	13 14	97 77	61 51	30 18	6 25	
ter-beds.	Sewage, November, 1899..	1 486	.438	.219	.219	7 07	3 54	8 86	4.1
	Effluent, " " .	1.374	.024	.024	.000	1 61	1 61	8 13	
	Per cent. removed ..	7 53	94 52	89 04	100 00	77 23	54 53	7 87	
Average of both methods	Sewage, November, 1899. .	1.595	.553	.264	.290	7.08	4 99	7 36	15 9
	Effluent, " " .	1 503	.194	.189	.005	3 33	3 33	7 53	
	Per cent. removed	5 77	65 15	30 08	98 28	50 65	35 47	3 30	

during the warm weather. In either case, still better chemical results would be expected when the water from North pond is diverted from the sewage.

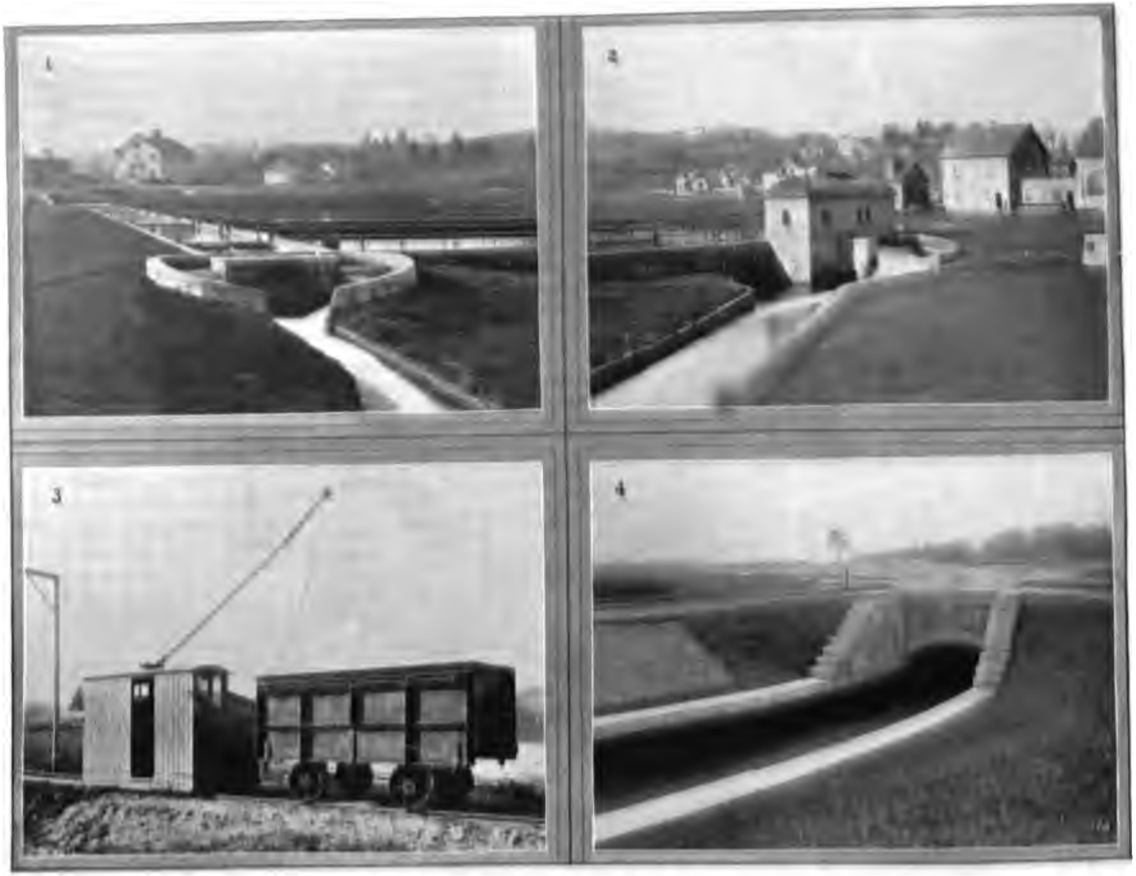
An average of 1,204 pounds of lime per million gallons of sewage has been used in this treatment.

INTERMITTENT FILTRATION.

The filter-beds have been put into use as fast as completed, and considerable progress has been made in getting them into working condition. During October and November, however, the large amount of acid in the sewage was taking so much lime that large quantities were turned onto the filters. In order to treat as much water as possible in this way, the weakest sewage containing strong acids was selected for the filters. The results of this treatment are given in Table XVII, as are also those of the chemical precipitation, so that a comparison can be made. It should be remembered that a quantity of sewage many times in excess of the capacity of the filters has been applied to them, which will partly account for the inferior quality of effluent they have produced, and also that they could not be used in this way very long before becoming clogged to such an extent that the quantity of water applied would have to be greatly reduced. During these two months, as many as four beds have been out of use on account of cleaning.

SLUDGE DISPOSAL.

The disposal of the sludge from the chemical treatment has been an important feature of the work. About 70.1 million gallons of sludge have been removed from the settling-basins. This amounts to 1.17 per cent. of the entire flow of the sewage. Of this, 17.5 million gallons have been pumped on to the sludge-beds at times when the presses were unable to take the entire amount produced, and the balance of 52.6 million gallons have been pumped into the storage tanks. After this sludge had been allowed to settle for several hours, considerable supernatant liquid has been drawn off. This, however, has amounted to but 1.85 per cent. of the sludge pumped into the basins. The reason this per cent. is not higher is because when the



CUT 8.

VIEWS AT PURIFICATION WORKS.

largest quantity of sludge is being pressed, there is not sufficient storage to allow a suitable settlement before an attempt is made to draw off the clear water.

About one ton of lime daily has been added to the sludge since the large amount of pickling-liquid has been discharged into the sewage. The precipitate of hydrate of iron formed by the action of the lime on these liquors is extremely bulky, and much more difficult to press than the sludge without the excess of iron in it. What water has been drawn from these basins, and the filtrate from the sludge-presses, has been filtered on gravel filters. For this purpose four half-acre beds have been provided.

The statistics of interest in connection with the sludge pressing have been kept very fully since the plant was first put in operation. These are presented in Table XVIII. It will be noticed that 24,992 tons of sludge-cake have been produced, and that the cake has contained nearly 75 per cent. moisture. It has proved more economical to press the sludge in this way, than to attempt to reduce the cake to 60 per cent. moisture. The cake is readily removed from the presses, and soon dries on the dump, thus saving the expense of making a dryer cake.

The sludge-presses have proved very satisfactory, but as was anticipated are not of sufficient capacity to do all the pressing at times of unusually large production of sludge as the past year has been.

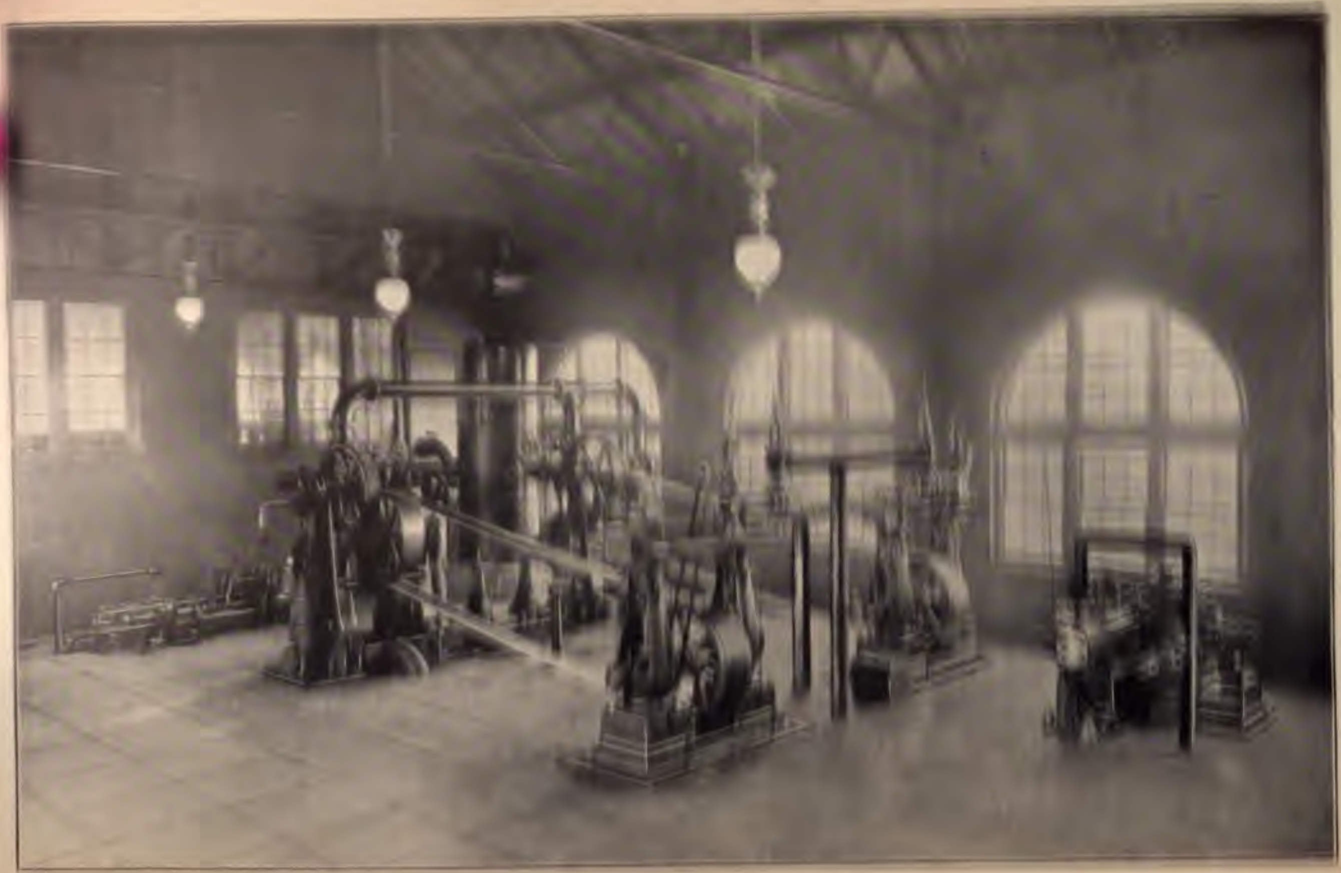
CONDITION OF THE BLACKSTONE RIVER.

The studies of the condition of the Blackstone river have been continued as in former years. It will be seen from Tables XIX to XXI that the condition of the river has not been as good as in 1898. This is very largely due to the great decrease in the amount of water flowing. Since the Kettle brook system was added to the water supply there has been a marked reduction in the flow of the river. There has also been considerable pollution of the stream by riparian owners. As sewers have been provided for several of these, it is expected there will be an improvement in this respect in the future.

Table XVIII.

RESULTS OF SLUDGE PRESSING.

MONTHS.	Sludge Pumped (Mil. Gals.)				Tons Solids.			Tons Cake.					Cost of Labor, Coal and Lime.	Cost per Ton of Solids.
	From Settling Basins.	To Filter Presses.	To Sludge Beds.	Total.	In Pressed Cake.	On Sludge Beds.	Per Cent. Solids in Wet Sludge.	Total.	Pressed.	Sludge on Beds.	Per Cent. Solids in Cake.	Pounds of Lime Added to Sludge.		
December,	2.7	2.7	...	471	471	....	3 32	1,683	1,683	....	28.0	......	$1,507 84	$3 20
January,	2.9	2.9	...	396	396	....	3.36	1,288	1,288	....	30.7	.....	1,670 02	4 22
February,	3.2	2.7	0.5	413	345	68	3.09	1,435	1,199	236	28.8	......	1,485 75	4 31
March,	3.1	3.1	...	502	502	....	3.96	1,636	1,636	...	30.7	51,000	1,564 98	3 12
April,	3.8	3.8	...	491	491	....	3.15	1,819	1,819	....	27.0	67,400	1,783 68	3 62
May,	8.2	6.1	2.1	873	654	219	2.58	3,745	2,806	939	23.3	48,000	2,011 78	3 08
June,	8.3	5.9	2.4	997	709	288	2.91	3,639	2,588	1,051	27.4	84,000	2,092 07	2 96
July,	8.6	6.9	1.7	1,078	863	215	3.04	3,922	3,139	783	27.5	90,000	2,306 41	2 67
August,	9.3	6.4	3.0	1,096	747	349	2.85	4,297	2,931	1,366	25.5	96,000	2,234 40	2 99
September,	9.2	5.7	3.5	1,021	629	392	2.69	4,306	2,654	1,652	23.7	32,000	2,054 72	3 28
October,	5.4	4.0	1.4	670	493	177	3.01	2,747	2,020	727	24.4	74,000	1,683 29	3 41
November,	5.5	2.6	2.9	644	306	338	2.86	2,584	1,229	1,355	24.9	41,660	1,287 14	4 04
Total,	70.1	52.6	17.5	3,652	6,606	2,046	2.99	33,101	24,992	8,109	26.1	584,060	$21,682 08	$3 27
Other expenses													9,051 65	
Total													$30,683 73	$4 64



CUT T.

ENGINE-ROOM AT PURIFICATION WORKS SHOWING ENGINES AND PUMPS, PRESSURE TANK, HYDRAULIC PUMP, AND DIRECT CONNECTED ENGINE AND DYNAMO.

TABLE XIX.

Averages of Weekly Analyses of Water from the Blackstone River from December, 1898, to July, 1899; July, 1899, to December, 1899, and from December, 1898, to December, 1899.

(Parts per 100,000.)

Where taken.	Dates of collection.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Washburn & Moon Pond	Dec. 1, 1898, to July 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " "	July 1, 1899, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " "	Dec. 1, 1898, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bridge	Dec. 1, 1898, to July 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	July 1, 1899, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Dec. 1, 1898, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Swamp	Dec. 1, 1898, to July 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	July 1, 1899, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
"	Dec. 1, 1898, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mason Pond	Dec. 1, 1898, to July 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	July 1, 1899, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	Dec. 1, 1898, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aldrich Pond	Dec. 1, 1898, to July 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	July 1, 1899, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" "	Dec. 1, 1898, to Dec. 1, 1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table XX.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1899 INCLUSIVE.

	TOTAL ALBUMINOID AMMONIA. (Parts per 100,000.)							PER CENT. IMPROVEMENT.						
	1893	1894	1895	1896	1897	1898	1899	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98	'98-'99	'93-'99
Washburn & Moen's Pond.														
December to July	......	.023	.032	.025	.022	.024	.027	....	39.13	21.25	12.00	-9.09	12.50	....
July to December	.052	.054	.050	.042	.037	.039	.085	3.84	7.41	16.00	11.91	5.41	117.95	63.16
Average for year	.047	.037	.039	.032	.028	.030	.051	21.28	-5.41	17.05	12.50	7.14	70.00	8.08
Blackstone River, Bridge.														
December to July	....	.047	.050	.047	.037	.047	.076	......	6.38	6.00	21.27	27.04	61.70	....
July to December	.085	.062	.056	.060	.048	.071	.070	27.06	9.68	-7.14	20.00	47.92	1.41	17.65
Average for year	.103	.053	.052	.053	.042	.057	.073	48.56	1.89	1.92	20.75	35.72	-28.07	29.13
Blackstone River, Swamp.														
December to July	.....	.129	.109	.096	.085	.115	.110	....	15.50	11.93	11.46	26.08	13.04	......
July to December	.377	.178	.189	.150	.137	.105	.135	52.79	21.91	-7.91	16.33	20.95	-28.57	64.19
Average for year	.282	.150	.122	.118	.103	.111	.114	46.81	18.67	3.28	12.71	-7.21	2.70	24.11
Morse's Pond.														
December to July	......	.108	.098	.097	.082	.067	.081	....	13.89	-4.30	15.46	18.29	-20.94	....
July to December	.211	.157	.157	.141	.119	.121	.139	25.60	00.00	10.19	15.61	1.68	6.61	38.86
Average for year	.175	.129	.120	.115	.098	.089	.100	26.29	6.98	4.17	14.78	9.18	-12.36	42.86
Aldrich's Pond.														
December to July	......	.101	.082	.088	.074	.061	.075	....	18.81	7.32	15.91	17.57	22.95	.....
July to December	.172	.151	.182	.152	.108	.168	.088	12.21	0.66	13.16	18.18	37.04	50.60	51.74
Average for year	.185	.122	.112	.106	.089	.064	.078	9.63	8.20	5.36	16.03	28.08	21.88	42.22

TABLE XX. *Continued.*

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1899 INCLUSIVE.

	TOTAL OXYGEN CONSUMED (Parts per 100,000.)							PER CENT. IMPROVEMENT						
	1893	1894	1895	1896	1897	1898	1899	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98	'98-'99	'93-'99
WASHBURN & MOEN'S POND														
December to July		0.74	0.75	0.64	0.59	0.48	0.73		1.35	14.67	7.81	18.64	52.08	
July to December	1.21	0.87	1.14	0.64	0.67	0.77	1.42	28.10	31.04	43.86	4.69	14.93	84.42	17.36
Average for year.	1.03	0.79	0.90	0.64	0.62	0.60	1.01	23.30	13.91	28.89	3.12	3.23	68.33	1.94
BLACKSTONE RIVER, BRIDGE														
December to July		0.95	0.96	0.72	0.74	0.88	1.08		1.05	25.00	2.78	18.92	22.73	
July to December	1.40	0.95	1.05	0.76	1.08	1.00	1.44	32.14	10.53	27.62	42.11	7.41	44.00	2.86
Average for year..	1.51	0.95	1.00	0.74	0.88	0.96	1.24	37.09	5.26	26.00	18.92	9.09	29.17	17.88
BLACKSTONE RIVER, SWAMP.														
December to July.		1.21	1.30	0.80	0.89	1.02	1.03		7.44	38.46	11.25	14.61	0.98	
July to December . . .	2.41	1.60	1.24	1.23	1.24	1.10	1.55	33.61	22.50	0.81	0.81	11.29	40.91	35.68
Average for year .	2.12	1.36	1.27	0.99	1.04	1.08	1.24	35.85	6.62	22.05	5.05	3.85	14.81	41.51
MORSE'S POND.														
December to July . . .		1.17	1.15	0.94	0.92	0.65	1.01		1.71	18.26	2.13	29.35	55.38	
July to December . .	1.37	1.41	1.24	1.08	1.07	1.12	1.54	2.92	12.06	12.90	0.93	4.67	37.50	12.41
Average for year . .	1.43	1.27	1.19	1.00	0.98	0.84	1.20	11.19	6.30	15.97	2.00	14.29	42.86	16.08
ALDRICH'S POND.														
December to July . .		1.12	0.95	0.90	0.79	0.87	0.75		15.18	5.26	12.22	10.13	16.00	
July to December	1.18	1.27	1.08	0.89	0.85	0.86	1.48	7.63	14.96	17.59	4.49	1.18	72.09	25.42
Average for year . .	1.09	1.18	1.01	0.90	0.81	0.87	1.05	8.26	14.41	10.89	10.00	7.41	20.69	3.67

TABLE XXI.

CONDITION OF BLACKSTONE RIVER BELOW SEWAGE PRECIPITATION WORKS.

FROM STATE BOARD OF HEALTH

Parts per 100,000.

MONTHS.			Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		[illegible]
				Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
							Total.	Dissolved.	Suspended.				
June	November,	1887	0 91			.2656	.1741			1 35	0100		
"	"	1888	0 76			.2658	.1112	.0557	0555	1 50	0152	0011	
"	"	1889	0.86			.3050	.1430	.0772	.0058	1 32	0177	0026	
"	"	1890	0.97	11.36	3 10	.2007	.1402	.0732	0770	1 40	0270	0018	3 0
"	"	1891	1.05	22 25	6.60	.6307	.1508	.0583	.0025	2 01	0244	.0040	6 2
"	"	1892	0 68	26.80	7 75	5240	.1810	.0058	.0552	3.13	0137	0050	10 3
"	"	1893	0.51	30.00	7.13	.5080	.1453	.0000	0553	2 70	0280	0126	10 0
"	"	1894	0.40	29.80	5.86	.6180	.1390	.1113	0277	2 03	.0212	0071	10 6
"	"	1895	0.71	22.15	5.18	.3240	.0898	.0597	.0301	1 80	.0207	.0063	7 3
"	"	1896	0.80	26.08	6.58	2831	.0808	.0000	.0208	2.10	.0217	.0118	9 7
"	"	1897	0.78	25.98	4 97	.3650	1122	.0782	.0340	1 01	0207	0063	6 0
"	"	1898	0 28	25.68	6.78	.8064	.0868	0560	0308	1 56	0132	0120	9 2
"	"	1899	0.14	44.02	0 67	.5261	.1707	0012	.0706	3 20	0108	0006	1 6

SLUDGE-PRESSING PLANT.

The filter-pressing plant, which was put in use in 1898, and which has run continuously since that time, has been finally completed during the past year, and, as it has never been reported upon, it seems wise in the present statement to go somewhat fully into the detail of construction.

Throughout the studies on this subject the fact was kept constantly in mind that rapid progress was being made in the purification of sewage by other processes than chemical precipitation, and on this account as little machinery was purchased as it was possible to get along with and do the work required. All plans were made, however, with a view to future additions should the present method of sewage treatment be continued.

The first consideration was that of suitable storage for the sludge. As it was impracticable to press it as rapidly as it was pumped from the settling-basins, it became at once necessary to provide storage-basins, or to allow it to remain in the settling-tanks until it could be disposed of by the presses. If the latter method was adopted, several of the basins would be continually idle, so far as their especial function, viz., the treatment of sewage, was concerned. This would hardly be an economical method, as there would never be more than a few feet of sludge in a basin, and the pumping would be so slow that the force required to clean the tanks would be largely increased. It became evident, then, that special basins for the storage of the sludge should be provided. Accordingly, two masonry basins, 20 feet by 66.66 feet by 11 feet, were built. Each has a capacity of 100,000 gallons when filled to within one foot of the roof. These tanks were covered to prevent trouble from ice in the winter. The roof was flat, and consisted of 15-inch I-beams, spaced four feet apart, and filled between with Portland cement concrete. A gate was placed in the partition-wall so that the sludge could be drawn out of one basin through the other in case of accident to the suction-pipe.

By allowing the full basins of sludge to stand at rest for several hours, it has been found that from 25 per cent. to 35 per cent. of clear water can be drawn off the surface in a condition suitable to be run onto the gravel-filters, where it can be further purified. This, of course, results in a saving of from 25 per cent. to 35 per cent. in the amount of liquid to be pressed out of the sludge, and consequently about an equal saving in the cost of operating the plant.

It was hoped at the outset that the pumps and the presses would be able to take the sludge without previous screening. This, however, has not proved to be the case, as perhaps is not remarkable when it is considered that the sewage is not screened. Very little trouble was experienced with the presses before the screens were put in, but the pumps clogged occasionally.

The storage-basins are filled by the Shone ejector, which is so connected by pipes that the sludge, when the basins are full, may be pumped onto the sludge-beds. When lime is added to the sludge, it is admitted just before running into the ejector, thus being thoroughly incorporated before reaching the basin. Milk of lime is used, and is conveyed by gravity from the lime-mixing tanks in the main building by a six-inch pipe.

The sludge is forced into the filter-presses by direct pumping. For this purpose two 8x12-inch, triple-plunger, belt-driven pumps were installed. They were built by the Deane Steam Pump Co., of Holyoke, Mass., and were designed as "stuff" pumps for paper-mill use. See Cut T. They were selected for this use because there were but six valves in each pump, two for each plunger, all of which were easily accessible, and not liable to clog. The valves consist of bronze balls, about six inches in diameter, seating on bronze seats about five inches in diameter. The passages through which the sludge flows are all large and straight, with but few turns, and these of reasonably long radius. Two double 9x9-inch vertical steam engines are belted direct to the driving-wheels of the pump. These engines run at 160 revolutions per minute, and the pump speed is reduced to forty-five revolutions per minute by gear and pinion on the pumps. Either of these pumps will deliver the full capacity of the four filter-presses, so that there is practically a duplicate plant. At times, however, the sludge is very thin, and then both pumps are needed at the same time, although only for a few minutes, when the sludge is first admitted to an empty press. The engines are regulated automatically by the pressure of the air in the top of the pressure-tank. The pumps are piped so that either can be used to pump the sludge from the settling-basins to the storage-tank in case of accident to the ejector. The sludge is forced through the presses under a pressure of 80 pounds per square inch, passing through a 1,130 gallon pressure-tank. This tank is kept only three-quarters full of sludge, the space above being filled with air. This serves as a cushion, and provides a steady pressure. A small Ingersoll-Sergeant air-compressor, 6x6x6 inches, furnishes the air necessary for this use. The pressure-tank stands on end, and from its bottom a 10-inch pressure-main runs along close to the head end of the presses. From this main 6-inch feed-pipes run to the individual presses. These pipes are fitted with 6-inch Chapman gate valves, provided with 2.5-inch by-pass valves.

The filter-presses, of which four have been installed, were built by the G. H. Bushnell Press Co., of Thompsonville, Conn. In brief a filter-press may be said to consist of one stationary end or head with parallel, horizontal side rods running at right angles to this head at a proper height from the floor, from which they are supported, and upon these rods a number of movable diaphragms are supported. These diaphragms are dished on both sides. Over them are hung cloths. The other end of the press is movable. When it is desired to fill the press the movable head is forced towards the fixed head, carrying with it the movable diaphragms until all are tight together. The sludge being admitted to the press is forced, by its pressure, into the spaces between the plates, passing from one chamber to the next through the six-inch hole in the middle of each plate. The water passes through the cloths, leaving the solids between the diaphragms, which are moved back at the suitable time toward the movable head, which has been previously drawn several feet away from the nearest diaphragm. This allows the pressed cake to drop out. The description of the presses will be easily followed by reference to Cut U.

The side rods are rectangular in section and are supported by [illegible] legs. They are forged down to a round section at one end and threaded. The ends are passed through [illegible] and the cylinder yoke at the foot of the press [illegible] fastened by tightening the nuts on each [illegible]. These rods are [illegible] smooth [illegible] forming a good [illegible]

[illegible] bronze rolls, two on each side [illegible]. This ram can travel about four [illegible] by hydraulic pressure [illegible] is provided to draw [illegible] a pressure of eight [illegible] pressure of 2,000 pounds on [illegible] the pressure [illegible] to overcome [illegible] With these [illegible] operating the [illegible] allowing [illegible]

[illegible]

[illegible] and from these [illegible] machine. The [illegible] a flow of [illegible] in the lower [illegible] corrugations. Holes are [illegible] into the [illegible] and [illegible] corrugations into these [illegible] in the corrugations, [illegible] lower parts of the plates.

[illegible] AN[illegible]
[illegible]ATIONS.

The grooves collect it and discharge into the corrugations near the perimeter, whence it runs through the small perforations into the inside and then out. The corrugations are made as deep as practicable. Each filter cloth is composed of two pieces of duck, each large enough to entirely cover the face of the plate. A centre hole, about five inches in diameter, is cut in each piece and the two are sewed together around this hole. One piece of this now double cloth is pushed through the hole in the centre of the plate, and then the two pieces are so placed as to cover the plate. The upper part of the cloth is held in position by screw-hooks, which are adjustable to allow of taking up the cloth to make it lie smooth. The plates are supported on bronze rolls, one on each side of the plate, bearing on steel pins. These rolls travel on the side bars of the press. Each plate weighs 380 pounds and is easily moved on the rails by two men, each using one hand for pulling the plate and the other for cleaning the cake from the cloth. The plates have a diameter, over all, of about 39 inches and a concave surface of 36 inches. Surrounding the concave surfaces are narrow rims properly faced to form water-tight joints with adjoining plates. Guide plates, 1/8 inch thick, are fastened to the inside of the legs of the presses at an angle of sixty degrees. These plates prevent the sludge from falling to the press floor.

The presses rest upon piers about three feet apart, with one set of legs on each pier, the press thus being over the pit between piers. On the floor below the press room a double track, having a three-foot gauge, is laid in front of the piers. At the end of this track a transfer car serves to transfer the sludge cars from one track to the other. The cars are placed opposite the presses and are loaded with sludge by conveyors.

These conveyors consist of troughs running the entire length of each press-pit. The sludge drops into these troughs and is carried to the foot end by six inch iron lugs, carried on endless wire cables working in the troughs.

From here it falls into the car which is waiting. The only labor required in this connection is that of leveling off the load and pushing along the car occasionally. The four conveyor cables are driven from a main shaft, each pulley being supplied with a clutch, which is run by a General Electric Co. motor, type C. E., wound to develop 5 H. P., at 350 revolutions and 220 volts.

The sludge cars are hauled by electric motor cars to a dump nearly a mile from the press house. The motor car is of peculiar shape and very small on account of the space through which it has to pass in the building. (See Cut S.) An overhead trolley line supplies the necessary current for these cars. The sludge is dumped from a trestle about 20 feet high.

The only expense connected with this final disposal is that of hauling the sludge to the dump. The sludge cars are made entirely of iron. (See Cut S.) The bottoms have a sharp pitch from the centre towards the sides and the side doors are hinged at the top. When a car is in a position for dumping, the motorman removes the key and the doors are at once forced open and the load slides out. He then closes the doors by means of a gear and pinion and starts on the return trip. The round trip can easily be made in 20 minutes, the time of cleaning one press. Four sludge cars and two motor cars constitute the equipment for removing the sludge cakes. Each car has a capacity of three yards and holds the contents of one press.

It is intended to wash the press cloths once each week. For this purpose a washing machine and extractor have been put in. They are operated by an electric motor, formerly used on the motor boat in Millbrook. The washer is 36x48 inches, and the extractor has a 28-inch basket and runs at 360 revolutions per minute. Both machines were made by the Troy Laundry Machinery Co. of Troy, N. Y.

The electric power and light are generated by a Westinghouse six-pole, 20-kilowatt compound generator, giving a potential of 220 volts. The generator is direct connected to an 8x8-inch Alfree straight-line, high-speed engine. This equipment should be duplicated as soon as the necessary money can be obtained.

The switch-board is equipped with the necessary measuring instruments, a circuit breaker and eight circuit switches. The press building is lighted by eight 1200 candle power, constant potential, enclosed arc lamps, made by the Jaundis Electric Co. The rest of the plant is lighted by incandescent lamps.

[illegible]
[illegible]

[illegible] AND
[illegible]

[illegible]

Filter Beds at Purification Works

Pressure for the hydraulic rams of the filter presses is furnished by a duplex, 14x2x10 inch pump made by Deane Brothers and furnished by the G. H. Bushnell Press Co.

The boiler plant consists of two 40 H. P. return tubular boilers made by C. Stewart & Sons of this city.

The filter-press plant is very complete, although no unnecessary machinery has been purchased. It has done even better work than was expected when the orders for it were placed. The building in which it is housed is of suitable size, and is convenient. Duplicate machinery may have to be provided as the future growth of the city may necessitate, but at the present time few improvements have suggested themselves.

FILTER BEDS.

The construction of filter beds, which was begun in 1898, has been continued during the past season. This work was finished in the fall, when fourteen beds were completed. Each bed has an area of one acre, and is about six feet deep to the top of the underdrains. All beds are thoroughly underdrained, and provision has been made for the treatment of a large amount of sewage on each bed. In fact the beds have been so constructed throughout that they may be used experimentally, which was the essential motive in their construction. The filtering material is excellent, and it is hoped that much information will be obtained from the experiments performed. (See Cut V.)

Some of the filters have been in use several months, the general results appearing in Table XVIII.

MAINTENANCE.

This branch of the work of the department naturally divides itself into four distinct classes.

TABLE XXII.

Money expended in different divisions of maintenance:

Total cost of new catch-basins built..............	$7,122 28
Total cost of repairing old catch-basins, man-holes and sewers	4,089 10

Total cost of cleaning sewers and catch-basins	2,185 14
Total cost of work chargeable to other parties	4,977 15
Total expenditure in maintenance account	$18,373 67

The only work not essentially a work of maintaining the system is that of building new catch-basins. When surface water sewers are put in the necessary catch-basins are constructed and charged to the account of that sewer, which is a charge against the construction account and not against that of maintenance. There are, however, a large number of basins built each year on old lines of sewers which are charged to the maintenance account. This year 166 basins have been built, 35 of which have been chargeable to other accounts or to outside parties. This is nearly 100 basins more than are usually built during one year. It would seem, however, to be an economical plan to build as many basins, which are badly needed, as money can be spared for. The saving to the Street Department, by preventing washing away of the roadbed in places where catch-basins are needed, would in most cases pay for the construction of the basins in one year.

A large amount of work is done each year to repair catch-basins and man-holes interfered with by the work of other city departments and by corporations having rights to dig up the streets. This work is entirely paid for by the parties necessitating the same. It seems unfortunate that this work should be necessary, but there appears to be no way of preventing it in a growing city like Worcester.

About the usual amount of repairs has been made upon the sewers, man-holes and catch-basins. The Shrewsbury street sewer has been rebraced and has not caved in during the year, which is a cause for congratulation. It is absolutely necessary that this sewer be rebuilt, and it cannot be done too soon. It would be a serious matter if this main should fail, especially during the winter season, when it would be almost impossible to repair the damage.

The catch-basins and sewers have been systematically cleaned and flushed during the past year. The rapidly-increasing mileage of sewers and number of catch-basins require an ever-increasing amount of cleaning. The past season has been a very favorable one for this work, as there have been few rains and scarcely any heavy showers.

The sewer system, with the exception of the Shrewsbury street sewer, is in very good condition and no unusual repairs will be necessary during the coming year.

In closing it is a pleasure to acknowledge the encouragement, advice and support which have at all times been received from the members of the Committee on Sewers, individually as well as collectively. The work of the committee has often been performed at the personal inconvenience of its members, but always willingly and with the thorough investigation so necessary to the proper discharge of the duties devolving upon it.

The Committee on Sewer Assessments has devoted a large amount of time to the investigation of new assessments as well as to petitions for abatement of old assessments. In a number of cases the committee has viewed the locations to be assessed and given personal attention to the problems involved.

Throughout the year frequent suggestions and advice have been given by the City Engineer, which have been of great assistance and duly appreciated.

The work of the assistant engineers of the engineering department has been universally efficient, and especial credit is due Mr. Matthew Gault, the engineer in charge of this work.

Mention should also be made of the faithful and efficient manner in which the various assistants and foremen have attended to their duties, and particular credit is due to Mr. Julius W. Bugbee and Mr. George H. White for the valuable assistance rendered in the department of purification and construction respectively.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

Worcester, Mass., Dec. 15, 1899.

A RESUMÉ

OF THE

Studies and Progress made toward the Solution

OF THE

SEWERAGE PROBLEM

OF THE

CITY OF WORCESTER, MASS.

WORCESTER
T. J. HURLEY, PRINTER, 38-44 FRONT STREET,
1890

To the Committee on Sewers:

In compliance with your request made March 9, 1899, I beg leave to submit the following Resumé of the Studies and Progress made toward the Solution of the Sewerage Problem:

In considering the problem in the light of what has been done and what must be done in the near future, and to get a complete knowledge of the whole situation with the reasons for the various steps taken, it is necessary to consider the topography of the city and the conditions as they existed in the years from 1865 to the present time.

The city is situated on hills and in valleys, there being but a small percentage of level land within its limits. As a natural result the drainage from the hillsides formed numerous small brooks. During the sixties the sewage of the 30,000 people living in the city was taken care of by cesspools and open ditches with a few covered pipes. The drainage found its way into the nearest brook, and then, as now, the drainage of the larger part of the city was ultimately received by Millbrook and carried by that stream to the Blackstone river. Several other brooks were used practically as sewers, among them Lincoln brook, Austin street brook, Hermitage brook, Piedmont brook and Pine Meadow brook. All of these, with the exception of Lincoln brook, were tributary to Millbrook.

In 1867, there having been for several years previous an agitation of the problem to better provide for the city's sewerage, an act was passed by the legislature granting, without reservation or conditions of any kind, the use of the brooks already mentioned for sewerage purposes, and in addition, the privilege was given to the city to lay whatever drains and common sewers might be deemed necessary, and to take and hold by purchase or otherwise such land, water rights, or other real estate as might be deemed necessary for the purposes of sewerage and drainage. At this time the city's population barely exceeded 30,000 people.

[illegible]

[illegible] sewage [illegible]

[illegible]

[illegible] the State Board [illegible] investigation of the question [illegible] the city of Worcester experi[illegible] of the Blackstone [illegible] a voluminous report [illegible]

[illegible] pages 14 and 20 of the [illegible]

[illegible] heat and cold of the climate. [illegible] of sewage, the diffi[illegible] disposal of the sewage of [illegible] any other town where the [illegible] any scheme that may be [illegible] to a certain extent; [illegible] a greater nuisance than it [illegible] system it must be costly in the original outlay, and involve [illegible] a considerable yearly expense."

"Whatever may be the means adopted to purify the sewage, the first step must be to separate it from the very great, but extremely variable, amount of water uniting with it in the brook, and to provide for the direct discharge of storm over-flows into the stream, thereby involving a considerable outlay of money [illegible] changing the present sewerage system of the city as to [illegible] these requirements."

After making a careful study of the flow of Millbrook and the discharge of the several sewers emptying into it the report of the board states "that it is evident that, to make practicable any scheme for utilizing or purifying the sewage, it must be intercepted before it reaches the brook." (Meaning Millbrook.) On page 21 of this report the following statement was made: "After careful consideration we have concluded to recommend the separate system of sewers for the valley."

This board concluded its report by recommending the system of intermittent filtration together with the separate system of sewers for the Millbrook valley. The board was advised in its studies of this problem by C. F. Folsom, M. D., of the National Board of Health, Joseph P. Davis, C. E., of New York, and Henry P. Walcott, M. D., health officer of the board.

From these extracts it is seen that as early as 1882 it was apparent to those who had studied the situation thoroughly that whatever the method employed for the disposing of the sewage of the city, it would be necessary, before success was attained, to remove the sewage from the surface water with which it had been mixed, by the authority from the state.

In 1884 a special commission was appointed by the Governor to consider and report a general system of drainage for the relief of the valleys of the Mystic, Blackstone and Charles rivers, and also to consider the various methods of disposal of sewage, and the application of such methods to any portion of the territories mentioned in the resolve.

The following abstract from the report of this board is of particular interest in connection with the opinion of many people so frequently expressed that the sewage of Worcester should be taken to the sea.

"It has been suggested that the State should [illegible] a trunk sewer from Worcester to the sea at Boston, and thus furnish the whole intervening territory with complete facilities at a blow. This scheme we consider to be entirely visionary and impracticable, for various reasons. In the first place, the engineering difficulties are very great, although not absolutely insuperable, as the heights of land between Worcester and Boston run north and south, separating the valleys of the Blackstone, Sudbury and Charles Rivers. Long and deep tunnels would be necessary, but it is possible to bore them. Then as a sewer once let down cannot be gotten up again without pumping the sewage, it becomes necessary in covering so great a distance to maintain a steady downward grade at a very slight and regular inclination for each mile. This aggravates excessively the difficulties of location and in consequence greatly stretches out the length of the route. It is not probable that a line could be found less than fifty miles in length. But even this does not put it beyond the bounds of possibility. Then, in consequence of its meandering course, which must be governed by topographical considerations, and could not be modified to meet the requirements of population, it cannot be carried from town to town like a railway, but must wind from hillside to hillside. This might, and probably would, compel towns not actually touched by the main sewer to spend more money merely to reach it than they would have to pay to treat their own sewage for themselves near at hand, should it be possible. All these objections are strong, but not absolutely conclusive. What we do consider, however, [illegible] to be entirely conclusive, is the enormous cost of such a work. We do not believe that it could be completed and put in operation for less than eight millions of dollars. And when it was done we should have a piece of machinery which would do no more and no better work than can be accomplished [illegible] for one-eighth of the money.

[illegible] the Commission was advised [illegible] Messrs. Joseph P. Davis [illegible] city.

[illegible] investigation and study [illegible] official boards and com- [illegible] becoming worse. In order [illegible] pollution of the river should be studied. This stream, being the result of the confluence of the various brooks flowing through the city of Worcester, runs rapidly through the State in a southeasterly direction, crossing into Rhode Island and finally emptying into Narragansett Bay. There is a very considerable fall between the head waters and the mouth of the river of which advantage was early taken by manufacturers. Dams were constructed and low lands along the river flowed to such an extent that the river had become, in 1885, a series of ponds rather than a running stream. The flood waters of many of the ponds flowed back to the foot of the dams above. The dams of course held back the current of the stream so that there was excellent opportunity afforded for sewage matter carried by the stream to settle in the various ponds. This was noticed at first in the ponds nearest the city, but gradually extended down stream for several miles, so that large quantities of sewage mud were contained behind the dams. In time of low water, when the banks were exposed and frequently also the deposit on the bottoms of the ponds, the odor rising was very noticeable.

These deposits, even when covered with water, were in a state of putrifaction, and the gases arising from the decomposition of the inorganic matter, passed through the water and into the air. Under these conditions, complaints became more frequent, and in 1886 the legislature passed the following statute requiring the city to provide some means of preventing the sewage from entering the river:

> "Statutes of 1886. Chapter 331. Section 1. - The city of Worcester shall, without being limited to any particular system, within four years after the passage of this act, remove from its sewage, before it is discharged into the Blackstone river, the offensive and polluting properties and substances therein, so that after its discharge into said river either directly or through its tributaries, it shall not create a nuisance or endanger the public health. ———

This act was approved by the Governor, June 25, 1886. The population of the city had reached 70,000 at this time.

In obedience to an order of the City Council approved September 22, 1886 the City Engineer, Charles A. Allen, submitted a very complete and extended report on the subject of the purification and disposal of the sewage of the city. In this

[illegible]

The [illegible] eminent [illegible] sufficient [illegible] Worcester, but the amount [illegible] unnecessary [illegible] years."

[illegible] reports which have been [illegible] from eminent sanitarians [illegible] the latter part of the [illegible] sewage of Worcester has been [illegible] nearly all of the engineers [illegible] matter of sewage disposal a [illegible]

[illegible] the city engineer spent a [illegible] the various methods of [illegible] with and obtaining expert [illegible] sanitary engineers of England. The [illegible] disposal works was an order [illegible] by which the outfall [illegible] and work upon this sewer was [illegible] after the passage of the order. [illegible] machinery at the purification works [illegible] by the City Council. Work upon [illegible] until the plant was complete and the [illegible] June 25, 1890.

At first only a small portion of the daily flow was treated and the work was wholly experimental in its nature. The amount treated was gradually increased until it reached about three million gallons in 24 hours. It was soon found, however, that the effect upon the river of treating so small a portion of the city's sewage was not as great as was expected and studies were at once begun to ascertain what course should be pursued to accomplish the greatest and best result in the shortest time. It was accordingly decided to increase the purification plant and an order to that end was passed by the City Council May 13, 1892. By this order the number of settling basins was increased from six, built under the order of 1888, to sixteen, and as a result of numerous experiments the entire method of preparing and admitting chemicals to the sewage was changed.

About the middle of July, 1893 the enlarged plant was put into operation and the amount of sewage was gradually increased to the maximum amount which could be forced through the outfall sewer. The effect on the river of this change was very noticeable but not as much as had been hoped so that in a comparatively short time complaints from the towns below the city became frequent.

In 1895 these complaints culminated in a suit brought by the town of Millbury against the city of Worcester before the Supreme Court to secure a decree compelling the city to comply with the Statute of 1886 cited above. This case was tried and the judgment of the court was as follows:

COMMONWEALTH OF MASSACHUSETTS.

WORCESTER SS.

SUPREME JUDICIAL COURT IN EQUITY.

THE SELECTMEN OF MILLBURY
VS.
THE CITY OF WORCESTER.

No. 547.

This cause came on to be heard at the May sitting of the court in the year 1896 upon the petition, the answer and the replication on file, and the proofs of the parties were taken before the court, and the cause was argued by counsel, and upon consideration thereof it appeared and was found by the court:

FIRST: That at the time of the filing of the petition on September 26, 1895, and prior thereto and thence down to the time of the hearing, the Blackstone river in Millbury was in a condition dangerous and predjudical to the health of the inhabitants of the town, and that the river in Millbury was a nuisance.

SECOND: That this dangerous and prejudicial condition and nuisance was due to several causes acting together, namely: (1.) To large deposits of old and filthy mud in the channel of the river in Millbury, and in all the mill ponds upon the river in Millbury, which deposits of mud were there before June 25, 1886, and have continued to be there ever since; (2.) To the putting into the river in Millbury of filth, sewage and manufacturing refuse, by the occupants of dwellings, shops and factories on the banks of the stream, and to like action on the part of the occupants of the banks of tributary streams falling into the Blackstone river in Millbury; (3.) To the putting into the river in Worcester above Millbury of manufacturing refuse and other filth by riparian occupants who put the same directly into the river and not through the sewers of the city of Worcester; (4.) To sewage collected by the sewers of the city of Worcester and discharged into the Blackstone river, without treatment to remove from it before its discharge the offensive and polluting properties and substances therein; (5.) To sewage discharged from the chemical precipitation sewage works of the city of Worcester and there treated, so that very much of its offensive and polluting properties and substances had been removed.

THIRD: That each of the causes specified is a substantial factor in making the river in Millbury dangerous and prejudicial to health and a nuisance, and that the river can never cease to be a nuisance while the old deposits of mud remain in its bed and ponds in Millbury, nor while an amount of the unpurified sewage of the city of Worcester as great as that now discharged into the river shall continue to be so discharged, while the discharge of the treated sewage from the purification works of the city, would not of itself alone create a nuisance in the river or endanger public health if the bed and ponds of the river in Millbury were cleaned from the old deposits of filthy mud, and the other causes above specified ceased to act.

FOURTH: The city of Worcester has acted with good faith under the Statutes of 1886, Chapter 331, and did within four years after the passage of the said statute, establish and put in operation purification works which upon reasonable investigation were apparently well designed and adapted to so treat its sewage that it should not create a nuisance or endanger public health, and have ever since kept their works in operation and from time to time have added thereto, and are now in good faith considering what further additions thereto are necessary to treat its sewage as required by the act cited.

FIFTH: That in fact the city of Worcester when this petition was filed, and prior thereto and since, to the time of hearing, has not effectually treated its sewage so that after its discharge into the Blackstone river it has not been a substantial factor in creating the nuisance and danger to public health above found.

And now upon consideration thereof it is ordered, adjudged and decreed that the court in these proceedings now has jurisdiction or equity to enforce the provisions of the act entitled "An Act to Establish a System of Sewage Disposal for the City of Worcester," approved June 25, 1886, and that the Respondent, the City of Worcester, be and is hereby ordered effectually to remove from its sewage, before it is discharged into the Blackstone river, the offensive and polluting properties and substances therein, so that after its discharge into said river, either directly or through its tributaries, it shall not create a nuisance or endanger the public health, and that the Respondent shall proceed with due diligence in obeying this decree.

That within three months from the entry of this decree the Respondent shall file in this cause a statement of the steps which it has taken since the filing of the petition, and that it proposes to take in further compliance with the provisions of of the Statute of 1886, Chapter 331, and that upon the filing of such statement the Selectmen of Millbury may file in the cause such suggestions as they may be advised.

That this cause be retained in court for such further proceedings as from time to time may be necessary and proper to ensure the performance of this decree and to enable the court to exercise the jurisdiction conferred by the statute above cited, and with liberty on the part of either party at any time to apply to the court for such orders or further decrees as may from time to time be necessary and just, and that the Respondents pay to the Petitioners their costs incurred to the entry of this decree, the same to be taxed by the clerk.

JAMES M. BARKER, J. S. J. C.

Pittsfield, December 14, 1896.

Immediately upon receiving the order from the court investigations were begun upon the course to be followed by the city, and in June, 1896, City Engineer Frederick A. McClure, presented the report to the City Council in which he recommended that the entire city be sewered according to the plan known as the separate system. This scheme requires two sewers in every street, one to receive the sewage from the houses and factories which would have its outlet at the purification works, and the other to receive the surface water from the streets, roofs and brooks and discharge the same into the nearest water course. This plan required the construction of two main intercepting sewers running nearly parallel with Millbrook and on either side of it. The west main carrier starts at "Cambridge street running through Quinsigamond avenue, Lafayette, Washington, Bradley, Green, Franklin, Vine, Cherry, Warren, Bridge, Manchester, Union and Exchange streets to a point near Cypress street. From this point two short locations will be required through estates, and by using existing courts and crossing the city property on Thomas street, exit can be gained on School street. By this route expensive excavations will be avoided. The route then passes through School, Main and Salisbury streets, from which point the laterals will extend to districts not drained through the east carrier."

The route selected for the east carrier is through Millbury street, beginning at Cambridge street, Water, Grafton, Summer and Lincoln streets to a point in the vicinity of Sawyer's lumber yard, there to pass through the rear streets to Garden street, thence to Prescott street and crossing south of Rural cemetary to Grove street."

These two main carriers, terminating at the corner of Cambridge and Millbury streets and at the corner of Cambridge street and Quinsigamond avenue, unite at this point and from there to the outfall sewer, the sewage is carried in a conduit constructed inside Millbrook sewer.

The estimated cost of this system is as follows:

East main carrier with laterals,	$346,685
West main carrier with laterals,	270,534
Southern and western districts,	215,520
Millbrook conduit,	45,000
Flushing tanks,	15,000
Total,	$892,739

This construction will require something over fifty miles of new sewers. The following conclusion of this report is of especial interest:

"In addition to what has been said in regard to the system of separation the most important element identified in the considerations, relates to the discharge of street wash into the streams through the surface water sewers. This feature requires recognition and is the only serious phase connected with the matter of separation, as a plan, there is to contend with, but from a careful study of the various schemes to isolate from the river all matters of objectionable nature, I am of the opinion that a separate system of sewers will best accomplish the desired result. The carrying out of any plan yet conceived of thoroughly disposing of all waste including street wash, in the vicinity of the purification works, carried doubtful features of utility which also are accompanied by questions of maintenance that raised the financial aspect to such proportions that favor the plan of separation. With better pavements and the inauguration of a system of street cleaning, that is a fact, this one phase, I believe, can be disposed of."

After this report had been presented to the City Council the following order was passed:

"Ordered: That the City Engineer be and he is hereby authorized and empowered to confer with such sanitary engineer and chemical expert as he may deem best upon the question of sewer separation, with the request to report the conclusions arrived at to the City Council, the expense of the same to be charged to the appropriation for sewer construction."

In obedience to this order Samuel M. Gray, of Providence, R. I., a distinguished civil engineer, who has made a specialty of sewage disposal, and Thomas M. Drown, president of Lehigh University, formerly at the head of the department of chemistry at Massachusetts Institute of Technology and chemist of the Massachusetts State Board of Health, were appointed to consider the problem of separation.

The following recommendations of these experts are of particular interest:

"We recommend as the first step toward the permanent and satisfactory solution of the question of the disposal of the sewage of the city, that intercepting sewers be built, and that the present combined system be connected with these interceptors. The entire dry weather flow of the sewage would then be taken to the precipitation works and no sewage would enter Millbrook except in the time of storm when the overflow of storm water would be discharged into it. This overflow would contain some sewage, but it would be very dilute and the duration of its discharge into Millbrook would be short.

When these intercepting sewers are completed, there will be an immediate improvement in the condition of the river from two causes. There will be as before, storm overflows, but there will not be, as at present, offensive deposits of sludge in Millbrook, to be washed out, and the sewage which will be carried into the river from the overflow will be more highly diluted than formerly.

It is not probable, however, that all cause for complaint will be thus removed, for a certain amount of sewage will still pass into the river at each overflow. Whenever an injurious pollution of the river is caused by this sewage, it will be necessary to parallel the existing combined system of sewers with a separate system, leaving the present sewers to carry the storm water only, which will then flow directly into Millbrook.

To what extent this will be required can only be decided by experience. The governing condition will always be the state of the river as affected by the amount of crude sewage passing into it.

We therefore advise, that the city take measures to provide for a gradual change from the combined to the separate system of sewerage, and that this change be carried on until the amount of crude sewage flowing into the river shall be inappreciable.

We further advise that the practice which you have already adopted of sewering the new portions of the city on the separate system, be continued.———

———There is a difference among experts as to the possibility of this effluent from the precipitation works causing a nuisance in the river by reason of the organic matter and lime which it holds in solution. The question is so complicated by the impure condition of the river that it is impossible to prove that it is or is not harmful. We think the weight of evidence is on the side of its harmlessness and this would seem to be the opinion of the court in its recent decree, in which it said:

'———While the discharge of the treated sewage from the purification works of the city would not of itself alone create a nuisance in the river or endanger the public health, if the bed and ponds of the river in Millbury were cleaned from the old deposits of filthy mud, and the other causes above specified ceased to act.'

But as long as any uncertainty exists as to the effect of this effluent on the river, it seems to us wise to have experiments carried on by the city in filtering this effluent on properly prepared filter beds, and we recommend that ten acres of land which the city now owns and which is admirably adapted for the puposes of filtration, be prepared by grading and underdraining to serve as experimental filter beds.

———The cost of the interceptors would be, according to our estimate, $293,500. A complete system of separate sewers would cost, in addition to the above about $600,000."

The report of these experts was filed by the city as its answer to the verdict of the court and the plan being accepted by the court is what the city is under obligation to carry out at the present time.

It has been deemed wise however, to carry out a portion of the engineer's report in regard to complete separation and a large amount of work has been done and the work which will be accomplished during the coming season will without doubt complete the separation of the surface water from the sewage in the southern and western portions of the city. These sections were selected as the surface water could be most readily diverted by turning it into Beaver Brook and also because the diversion of the storm water from the sewers of these sections would reduce the amount of water to be provided for by the Millbrook sewer south of Cambridge street, thus making it possible to devote a portion of the space in this sewer to the conduit for sewage only, which has been constructed.

As soon as practicable after this report was filed in court, the city secured from the legislature authority to borrow outside the debt limit the sum of one million dollars for the purpose of carrying out the recommendation. A clause was inserted in this act, however, transferring the loans which had been negotiated for the construction of the purification system to this authorized loan, so that only $670,000 were actually available for the purpose of separation. Work was immediately begun upon the conduit inside Millbrook running from Quinsigamond to Cambridge street, and also upon the South Worcester and West Side separating system. At the present time the work of resewering the South Worcester district is complete and the West Side system is complete as far north as Pleasant street and work is in progress upon orders which will complete the separation in this section of the city.

The construction of the main intercepting sewers had been pushed continuously from the time the work was begun and before the middle of the summer it is hoped to have them complete as far north as Franklin street on the west side and Winter street on the east side. It is very necessary that work on the intercepting sewers should be continued until they are complete as before that time the work done will be of little use. Work has also been done in preparation of a few acres of filter beds at Quinsigamond for the purpose of experimenting on filtration of the effluent and sewage, and these filters will be complete and ready for operation before summer.

The method of sewage treatment adopted by the city in 1890 and which is being carried out today is that known as chemical precipitation. This method is based upon the fact that when suitable chemicals are added to sewage a coagulation takes place and the impurities settle to the bottom of the basins through which they flow. It has been found that it is necessary to use nothing but lime as there are large quantities of sulphate of iron, known chemically as copperas, in the sewage when it is received at the [illegible] [illegible]. This copperas is in solution in the sewage, but as it comes in varying quantities at different times of the day, by utilizing the tanks for storage purposes it is possible to [illegible] the entire flow in sufficiently uniform quantities so that by the addition of lime a heavy precipitate is formed at all times. As the velocity of the flow of sewage through the basins is very slight this precipitate is afforded an opportunity to settle to the bottom, which it does, carrying the floating impurities of the sewage to the bottom also and leaving the liquid above comparatively clear. The sewage is allowed to flow continuously through the basins entering one end of one of them and flowing out at the surface at the other end and thence to the Blackstone. After the basins have been in use from one to three days it is found that the sediment in them has increased to such an extent that they must be cleaned. This sediment or mud at the bottom of the basins is technically known as sludge. It is pumped from the settling basins when it contains about [illegible] water, to the sludge storage basins where it is allowed to settle and a quantity of clear water is drawn off onto the filter beds. The sludge is then pumped into filter presses where the water is squeezed out from the solid matter so that the sludge contains only from 60% to 70% moisture. In this condition it can readily be handled by carts or teams and hauled onto farms where it is used as a fertilizer or taken to the dump and used for filling. The water pressed out of the sludge flows on to filter beds where it is purified in the same way as the effluent or sewage would be.

By chemical precipitation about 90% of the floating or solid impurities are removed from the sewage and a very small percentage of that in solution. The total purification, however, amounts usually to from [illegible] to 54 [illegible] of the organic or putrescible matter.

The organic matter which remains in the effluent is nearly all in solution so that the water looks clear and pure. This effluent can be further purified by intermittent filtration

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] wers.

ANNUAL REPORT

OF THE

SUPERINTENDENT OF SEWERS

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING MARCH 31, 1901.

Worcester, Mass.:
PRESS OF F. S. BLANCHARD & CO.,
158 FRONT STREET
1901

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

To the Honorable City Council of the City of Worcester.

In compliance with Section 21, Chapter 34, of the City Ordinances, the following report of the work and the condition of the Sewer Department for the fiscal year of 1900 is prepared.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

Office of the Sewer Department, December 15, 1900.

MEMBERS OF THE COMMITTEE ON SEWERS, 1900.

Alderman James B. Carberry, *Chairman.*
Alderman Louis J. Kendall.
Alderman W. Levi Bousquet.
Councilman Salmon H. Davis.
Councilman Lewis J. Terrill.
Councilman James P. Crosby.
Councilman John H. Connelly.

REPORT OF THE SUPERINTENDENT OF SEWERS.

A very large amount of work has been done during the year 1900. The construction of seventeen miles of sewers, several of them large, deep, and presenting many difficulties, together with the treatment of the sewage and the ever-increasing amount of work necessary for the proper maintenance and operation of the system, has required large expenditures and the employment of a large force of men.

During the season of the year when outside work could be done the number of men employed has averaged 553, and the maximum number on the rolls was 646, for the week ending Aug. 24, 1900.

The excavations have in several cases been very deep, a maximum of about thirty feet being reached in Grafton street. A variety of material has been encountered. Much of the time work has been carried on in rock, quicksand, and peat or muck; in the latter, piles had to be driven to provide suitable foundation for the construction. Ground water has been found on almost every piece of work, and has required constant pumping.

The financial statement is presented in Table I, which shows appropriations and revenues available for the use of this department, amounting to $516,444.04, of which $489,173.01 has been expended.

TABLE I.
SUMMARY OF FINANCIAL RESOURCES FOR 1900.

	Maintenance.	Construction.	Purification.	Statutes of 1897.	Statutes of 1900.
Bal. Dec. 1, '99	$2,428 18	$13 08	$13 63	$63,724 09	....
Appropriation	44,500 00*	42,891 46†	50,000 00‡	....	$200,000 00
Assessments..	....	35,620 22	....	....	....
Revenue.....	4,202 66	68,054 78	1,146 89	3,741 42	107 63
Total	$51,130 84	$146,579 54	$51,160 52	$67,465 51	$200,107 63
Total expen'd	50,382 82	146,577 76	51,160 28	67,465 51	173,587 24
Bal. Dec. 1, '00	$748 02	1 78	24	....	$26,520 39

* † ‡ Of these amounts $3,500. $10,000 and $5,000 were taken from license money respectively.

The revenue appearing as credited to the account of construction arises largely from the system employed for providing tools and supplies. For this purpose a shop-account is kept, and all supplies are charged to this account until used. In addition to this, the cost of delivery and of carpenter and machine work done is charged to this account. Each month bills are made out in favor of the shop, and are charged to the work upon which the materials are used. By this method, supplies can be purchased at much better prices than when they are obtained in small quantities for individual requirements.

Following is a schedule of the lengths of sewers built under the accounts of construction and separation, together with the number of man-holes and catch-basins:

GENERAL CONSTRUCTION.

Sewers	5.117	miles.
Surface water drains	1.405	"
Total	6.522	"

SEPARATING SYSTEM.

Sewers	8.487	miles.
Surface water drains	1.998	"
Total	10.485	"

TRUNK SEWERS.

Sewers	2.716	"
Surface water drains	.349	"
Total	3.065	"

Total miles of sewers	17.007	"
Total number of man-holes built		621
Total number of catch-basins built		166

Much-needed improvement of the shop and storage quarters has been afforded by the purchase of the land and buildings formerly occupied by Darling Brothers, and adjoining the property used by the Sewer Department on East Worcester street. This additional room has been developed gradually since it was acquired. The machinery has been moved from the old building to the second floor of the shop-building of the new property, and the lower floor of this building has been fitted up as a store-room.

While the work of the department is now well accommodated, there is no more room than is actually needed, and in fact one of the buildings should be torn down in the near future to provide more yard room.

One of the wooden buildings of the newly-acquired property has been fitted up as a stable. It is not a suitable place to keep horses in, and should be replaced by a good stable as soon as possible.

The machinery and tools are in good condition, although some of the hoisting-engines, which have done service for many years, will soon have to be replaced by more modern machines. Three Carson excavators have been hired, and the three owned by the department have been in use throughout the season. From two to four hoisting-engines have been hired as the work required.

TABLE II.

MATERIALS PURCHASED BY SEWER DEPARTMENT.

Material.	Contractor.	Price Paid.				Approximate Amounts Purchased.			
		1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Sand,	Emory S. Streeter,	$0.90	$0.75	$0.875	$1.05	1,819.5 cu. yds.	3,955.5 cu. yds.	4,450.9 cu. yds.	8,496 cu. yds.
Portland Cement,	Frank E. Powers,	2.15	2.05	1.98	1.95	3,260 bbls.*	8,551 bbls.*	18,885 bbls.*	8,006 bbls.*
Rosendale Cement,	Frank E. Powers,	0.86	0.71	0.84	0.98	6,894 bbls.†	3,694 bbls.†	2,770 bbls.†	8,363 bbls.†
Vitrified Pipe,	Portland Stoneware Co.,	......	......	......	......	....	42,305 ft.	94,077 ft.	89,185 ft.
Cement Pipe,	James Draper,	......	......	......	......	36,565.3 ft.	35,100.5 ft.	39,059 ft.	29,275 ft.
Brick,	Frank E. Powers,	7.20	7.40	8.60	8.85	2,658,100.	2,835,700.	2,334,093.	2,142,000.
Lime,	Frank E. Powers,	4.99	4.80	4.92	5.19	3,776 tons.	8,507 tons.	8,884.6 tons.	2,690.5 tons.

* One barrel equals four bags. † One barrel equals four paper bags.

The stock used in the construction of sewers and the treatment of sewage has been very similar to that used last year, and the quantities are not very different. Table II gives the quantities purchased and the contract prices paid for the same during the last four years.

TESTING LABORATORY.

Laboratory work has been continued as in previous years, and the results have proved of substantial benefit. When the contract for Portland cement was changed in May, the brand of cement was also changed, and considerable difficulty was experienced in obtaining cement of the quality which would satisfy the specifications of the contract. After making careful tests, it was found necessary to reject each of the first nine cars of Portland cement delivered by the contractor. After this the cement came better and there were very few rejections.

The method of testing cement remains the same as reported last year, except that steel spatulas are used for packing the paste into the moulds, rather than the wooden tampers formerly used. The records of cement test given in Tables III, IV, V and VI are the results of all the tests made. The long-time tests are especially interesting. It should be noticed that nearly all the brands of Portland cement tested show a decline in tensile strength at the end of eighteen or twenty-four months.

TABLE III

RECORD OF TESTS ON PORTLAND CEMENT NEAT. JUNE 1, [illegible], TO DECEMBER 1, [illegible]

BRAND	Number of Samples Tested	*FINENESS Per Cent Passing Through Sieve No. 50	No. 100	No. 200	TENSILE STRENGTH [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sp. Grav.	CHEMICAL ANALYSIS [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Atlas,	10				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alpha,	3				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alson,	8				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dyckerhoff,	9				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Egypt,	9				.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Germania,	1				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hecla,	1				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron Clad,	1					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lehigh,	1				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saylor's,	5				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Victor,	8				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Fineness tests made in [illegible] are omitted from the table because they are not comparable with the [illegible]

TABLE IV.

RECORD OF TESTS ON PORTLAND CEMENT NEAT. DECEMBER 1, 1898, TO DECEMBER 1, 1899.

BRAND.	Number of Samples Tested.	FINENESS. Per Cent Passing Through Sieve. No. 50	No. 100	No. 200	TENSILE STRENGTH. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Specific Gravity.	CHEMICAL ANALYSIS. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Total.
Atlas,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alpha,	8					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alsen,	8	. .			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dyckerhoff,	1	.	.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Germania,	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron Clad,	5	. .			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lehigh,	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nazareth,	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saylor's,	8	.	.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Standard,	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Star,	1	[illegible]	[illegible]	. .	[illegible]	[illegible]	.	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steel,	1	[illegible]	[illegible]	. .	[illegible]	[illegible]	[illegible]	. .					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vulcan,	8	. . .	. . .	. .	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE V.

RECORD OF TESTS ON ROSENDALE CEMENT—NEAT. JUNE 1, 1898, TO DECEMBER 1, 1898.

BRAND.	Number of Samples Tested.	*FINENESS. Per Cent. Passing Through Sieve. No. 50	No. 100.	No. 200.	TENSILE STRENGTH. 24h.	7d.	28d.	3m.	6m.	9m.	12m.	18m.	24m.	Specific Gravity.	CHEMICAL ANALYSIS. CaO	SiO$_2$	Fe$_2$O$_3$	Al$_2$O$_3$	MgO	SO$_3$	Loss.	Insol.
Hoffman,	6	......	......	......	106	161	255	348	384	387	400	405	435	3.197	34.23	24.30	5.23	6.04	21.23	1.33	4.25	1.33
Norton,	3	......	......	......	94	127	260	342	366	370	368	363	380	3.165	33.05	24.58	3.24	5.74	21.84	1.72	5.18	0.91
New York,	1	......	......	......	54	111	235	443	330	353	344	369	372	3.070	34.10	26.11	5.74	8.61	16.36	1.83	7.19	0.47
DECEMBER 1, 1898, TO DECEMBER 1, 1899.																						
Hoffman,	8	97.8	90.7	......	107	154	226	343	397	406	430	429	......	3.208	34.72	24.84	4.85	7.12	20.25	1.95	4.80	0.72
Norton,	13	95.8	87.1	60.5	74	118	174	238	262	283	276	......	......	3.174	34.78	24.33	4.48	6.27	21.07	2.24	5.54	0.60
New York,	3	......	......	......	73	96	184	365	451	467	462	506	......	3.127	33.06	26.86	3.40	10.34	16.45	1.80	5.40	0.77
DECEMBER 1, 1899, TO DECEMBER 1, 1900.																						
Hoffman,	17	97.8	88.4	69.7	89	120	219	338	406	......	......	......	......	......	......	......	......	......	......	......	......	......
Norton,	7	......	......	......	83	86	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Improved Rosendale,	1	99.8	98.0	89.1	122	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Obelisk,	1	97.6	91.8	83.8	94	132	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

*Fineness tests made in 1898 are omitted from the table because they are not comparable with the results from method in use since.

TABLE VI.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT. DECEMBER 1, 1899, TO DECEMBER 1, 1900.

BRAND.	Number of Samples Tested.	FINENESS.			TENSILE STRENGTH.					Specific Gravity.
		Per Cent. Passing Through Sieve.			24h.	7d.	28d.	3m.	6m.	
		No. 50.	No. 100.	No. 200.						
Alpha	1	99.31	91.74	73.72	228	636	752	......	......	......
Dragon	43	99.66	94.42	75.76	309	562	614	581	613	3.176
Krause	2	99.70	94.01	74.28	254	745	824	790	......	......
Lehigh	21	99.69	93.24	76.12	202	682	685	717	......	......
Nazareth	1	99.93	99.48	91.19	286	738	......	......	......	......
Phœnix	2	99.66	98.07	86.25	266	841	......	......	......	......
Roman Rock	1	94.00	80.90	66.60	118	184	......	......	......	......
Star	4	99.67	93.12	72.41	306	524	......	......	......	3.266
Standard	1	99.86	93.76	71.76	208	400	......	......	......	......
Storm King	1	96.70	87.30	74.40	178	291	......	......	......	......
Uncle Sam	1	92.50	80.00	67.50	144	313	......	......	......	......

Rainfall records have been kept at the purification works, and a study of their intensity is presented in Table VIII. The total rainfall is somewhat above the normal, although several inches less than recorded at either the Lynde brook or Holden reservoirs. The comparative frequency of rains during which the maximum 20-minute precipitation exceeded one-half inch is a matter of interest and worthy of consideration.

The work done in the laboratory has been more varied than in former years. A large number of tests and analyses have been made for other departments. This work has been done under the immediate direction of the chemist, Mr. Edward L. Smith, to whom special credit is due for the careful and accurate work done.

TABLE VII.

INCHES OF RAINFALL AT PURIFICATION WORKS, 1899-1900.

Day.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.
1	....	0.20	....	3.22	....	....	....	....	....	....	....	....
2	0.12	....	....	....	....	....	....	....	....	....	....	....
3	....	....	....	....	0.48	1.47	1.86	....	....	....	....	....
4	....	....	0.15	0.09	....	0.04	....	....	....	....	....	....
5	....	....	0.99	....	....	....	....	....	....	....	....	....
6	....	....	....	....	....	....	....	....	0.26	....	....	....
7	....	0.17	....	0.44	....	....	....	0.09	0.43	....	....	....
8	....	....	0.77	....	....	0.20	....	0.05	0.36	....	0.59	0.67
9	....	....	0.18	....	....	....	....	....	....	....	0.79	0.52
10	....	....	....	....	....	....	....	....	0.27	....	0.18	....
11	....	0.45	....	....	....	....	0.14	....	....	....	....	....
12	0.42	1.02	0.27	....	0.58	....	....	0.41	0.02	....	....	....
13	....	....	2.76	....	....	....	....	....	0.80	....	....	....
14	....	0.12	....	....	....	....	0.88	....	....	....	....	....
15	0.50	....	....	0.33	....	....	....	0.10	0.06	....	....	....
16	....	0.23	....	1.54	....	....	....	....	0.16	1.20	....	....
17	....	....	0.20	....	0.18	....	0.20	....	0.20	0.14	....	....
18	0.06	....	0.12	....	0.88	1.08	....	....	0.20	0.16	....	....
19	....	....	....	0.22	0.54	0.88	....	....	....	....	....	0.18
20	0.34	0.78	....	0.09	....	....	....	....	....	0.04	....	0.06
21	....	0.04	....	....	....	0.18	....	....	....	0.88	....	0.05
22	....	....	1.05	....	0.08	....	0.84	....	....	....	....	0.08
23	....	....	....	....	0.27	....	0.81	....	....	....	....	....
24	0.33	....	0.24	....	....	....	....	....	....	....	0.18	0.10
25	....	0.43	1.37	....	....	....	....	1.19	....	....	....	0.88
26	....	....	....	0.12	....	....	....	0.96	....	....	....	1.46
27	....	....	....	0.08	....	....	....	....	....	0.19	0.17	0.08
28	....	0.35	....	....	....	....	0.07	....	....	....	0.04	0.90
29	....	0.56	....	....	....	....	....	....	....	....	....	0.26
30	....	....	....	....	0.08	....	....	....	....	0.19	....	....
31	....	....	....	....	....	....	....	....	....	....	....	....
Total.	1.77	4.35	8.10	6.13	3.54	3.84	4.65	2.80	3.20	2.97	1.85	4.69

Grand total, 46.10.

		Duration of Storm.		Total Precipitation in Inches.	Rate per Hour in Inches.	‡20 Minutes of Maximum Precipitation.	Period of Greatest Precipitation.	
		Hours.	From				Hours.	From
December	2	2.7	3.40 A.M.	.12	.044	......	......	......
"	12	2.3	1.00 P.M.	.42	.183	.39	1.3	1.40 P.M.
"	15	9.0	1.20 A.M.	.50	.055	.18	......	......
"	18	......	......	*.06	......	......	......	......
"	20	5.3	2.00 P.M.	.34	.064	.18	2.0	2.20 P.M.
"	24	10.0	12.00 M.	.33	.027	.18	2.0	4.00 P.M.
January	1	7.3	6.40 A.M.	*.20	.027	.09	......	......
"	6-7	2.3	10.40 P.M. of 6th,	.07	.074	.12	......	......
"	11	......	......	†.05	......	......	......	......
"	11-12	8.7	8.00 P.M. of 11th,	†1.42	.163	.42	7.0	9.00 P.M. of 11th
"	14	5.7	4.20 P.M.	*.12	.021	......	......	......
"	16	3.3	8.00 A.M.	.23	.070	.12	......	......
"	20	16.7	6.20 A.M.	.78	.047	.69	8.0	7.00 A.M.
"	21	.3	1.40 A.M.	.04	.120	.12	......	......
"	25	10.7	9.00 A.M.	.43	.040	.30	2.0	11.00 A.M.
"	28-29	14.0	6.40 P.M. of 28th.	†.91	065	.12	10.4	8.20 P.M. of 28th
February	4-5	14 0	7.00 P.M. of 4th,	1.14	.081	.81	4.0	11.40 P.M. of 4th.
"	8-9	23.6	11 20 A.M. of 8th,	.95	040	.12	9.0	2.20 P.M. of 8th.
"	12-13	26.0	5.00 P.M. of 12th,	3.03	.117	.63	17.0	9.20 P.M. of 12th
"	17-18	16.3	4.20 P.M. of 17th,	†.32	.020	......	......	......
"	22	12.3	1.20 A.M.	1.05	.085	.30	3.7	8.20 A.M.
"	24-25	7.0	10.20 P.M. of 24th,	1.68	.233	1.38	6.3	10.40 P.M. of 24th,
March	1	23.0	1.00 A.M.	3.22	.140	.78	10.0	10 20 A.M.
"	4	6.0	12.40 P.M.	.09	.015	......	......	......
"	7-8	21.7	6.40 P.M. of 7th.	†.44	.020	.09	13.3	7.40 A.M. of 7th.
"	15-16	......	......	†1.87	......	......	......	......
"	19-20	7.3	7.00 P.M. of 19th,	.31	.042	.09	3.7	9.00 P.M. of 19th.
"	26-27	10.0	5.00 P.M. of 26th,	*.20	.020	.06	......	......
April	3	8.0	4.00 A.M.	.48	.058	.18	3.7	5.20 A.M.
"	12	8.7	10.40 A.M.	.58	.067	.12	6 3	11 00 A.M.
"	17	4.0	10.20 A.M.	.18	.045	.09	2.0	12.00 M.
"	18	7.3	2.00 A.M.	.27	.037	.12	......	......
"	18-19	11.4	5.20 P.M. of 18th,	.65	.057	.27	3.0	12.40 A.M. of 18th,
"	22	3.0	3.20 A.M.	.08	.027	......	......	......
"	23	4 0	9.20 P.M.	.35	.088	.15	......	......
"	30	......	......	.08	......	......	......	......
May	3	8.3	4.00 A.M.	1.29	.155	.48	......	......
"	3	1.7	5.00 P.M.	.18	.106	.27	......	......
"	4	......	......	.04	......	......	......	......
"	8	2.7	8.20 A.M.	.15	.056	.09	......	......
"	8	2.7	8.00 P.M.	.29	.107	.21	.7	9.40 P.M.
"	18-19	30.7	4.40 P.M. of 18th.	1.86	.061	.93	5.7	4.40 P.M. of 18th,
"	21	......	......	.10	......	......	......	......
June	3	1.3	4.00 A.M.	.22	.169	.51	......	......
"	3	9 0	2.00 P.M.	1.64	.182	.60	6.0	5.00 P.M.
"	11	1.3	6.20 P.M.	.14	.108	.12	......	......
"	14	1.0	6.40 A.M.	.07	.070	......	......	......
"	14	2.3	9.00 A.M.	.26	.113	.63	.3	11.00 A.M.
"	17	1.0	3.20 P.M.	.20	.200	.54	.3	3.20 P.M.
"	22-23	13.7	1.40 P.M. of 22nd,	1.15	.084	.54	......	......
"	28	1.7	11.20 A.M.	.44	.259	.78	......	......
"	28	1.7	6.40 P.M.	.53	.312	1.29	.3	6 40 P.M.
July	7	......	......	.09	......	......	......	......
"	8	......	......	.05	......	......	......	......
"	12	2.7	4.20 P.M.	.41	.152	.72	1.7	4.20 P.M.
"	15	......	......	.10	......	......	......	......
"	25-26	23.3	5.00 P.M. of 25th,	2.15	.092	2.49	1.7	5 00 P.M. of 25th.
August	6	2.0	10.20 P.M.	.26	.130	.54	.3	10.20 P.M.
"	7-8	8.7	7.40 P.M. of 7th,	.81	.093	.54	5.0	8.20 P.M. of 7th.
"	10	.7	3.40 P.M.	.27	.390	.69	.3	3.40 P.M.
"	12	......	......	.02	......	......	......	......
"	13	1.3	10.20 P.M.	.80	.231	.69	.3	11.00 P.M.
"	15	2.3	12.40 P.M.	.96	.417	2.19	.7	1.20 P.M.
"	16	......	......	.18	......	......	......	......
"	17	.3	1.00 P.M.	.20	.600	.60	......	......
"	18	......	......	.20	......	......	......	......
September	16	10.7	1.20 A.M.	1.20	.112	.27	7.0	2.00 A.M.
"	17	1.7	5.00 P.M.	.14	.082	.21	.3	5.20 P.M.
"	18	5.7	12.20 A.M.	.18	.032	.21	1.0	2.40 A.M.
"	20	......	......	.04	......	......	......	......
"	20-21	5.3	8.40 P.M. of 20th,	.37	.070	.51	.7	8.40 P.M. of 20th
"	27	4.0	12.40 A.M.	.19	.048	.12	1.3	2.20 A.M.
"	30	4.3	12.40 A.M.	.19	.044	.08	......	......
"	24	......	......	.18	......	......	......	......
"	27	......	......	.17	......	......	......	......
"	28	......	......	.04	......	......	......	......
October	8	......	......	.59	......	......	......	......
"	9	......	......	.79	......	......	......	......
"	10	......	......	.13	......	......	......	......
"	24	......	......	.13	......	......	......	......
"	27	......	......	.17	......	......	......	......
"	28	......	......	.04	......	......	......	......
November	8-9	39.3	3.40 A.M. of 8th,	1.39	.036	.87	4.7	4.00 P.M. of 8th,
"	19	......	......	.13	......	......	......	......
"	20	......	......	.06	......	......	......	......
"	21	......	......	.24	......	......	......	......
"	22	......	......	.08	......	......	......	......
"	24-25-26	42.7	7.40 P.M. of 24th,	2.44	.057	.36	12.0	2.00 A.M. of 26th.
"	27	......	......	.08	......	......	......	......
"	28-29	16.3	9.00 P.M. of 28th.	.46	.028	.18	12.7	9.20 P.M. of 28th.

*Snow. †Snow and rain. ‡Rate per hour in inches.

MAINTENANCE.

A large number of catch-basins have been built during the year. Of these 75 have been charged to the account of sewer maintenance, and 39 to the account of sewer construction. It has been the policy of the department to build as many catch-basins as possible with the money available, selecting locations where they were most necessary. An effort has also been made to build all the basins that will ever be required in the streets which have been improved by paving or macadamizing. The total number of basins built during the year is 133; of these 31 have been built at the expense of outside parties, and 5 were old basins rebuilt, leaving a net increase in the number of catch-basins of 128.

The large number of basins built each year of course adds to the work of cleaning, and to meet this, increased appropriations should be made. In the past twelve months, 16,321 cubic yards of refuse have been removed from the catch-basins. It is very necessary that they be cleaned often, so that they may be in a condition to take the water running in the gutters, and also that they may be able to hold back the detritus carried by the water, so that it may not enter the sewers and be deposited in them. The cost of removing a cubic yard of this material from the sewers is many times that of removing a like amount from the catch-basins.

The great increase in the extent of the sewer system of course adds materially to the cost of cleaning, and the various automatic devices required for the proper working of the system must receive considerable attention. Flushing and scraping have been systematically continued throughout the year.

The large amount of work done under ground by the New England Telephone & Telegraph Company, and the Worcester Electric Light Company, has necessitated extensive repairs upon catch-basins. The locations for wire conduits have, for the most part, been near the curb. At first the basins interfered with by the conduits were rebuilt in the sidewalks, but as this location proved very unsatisfactory it was decided to keep the conduits at least four feet away from the curb and adjust the shape of the catch-basins to meet this condition. The cost of all these changes and repairs is paid by the corporation causing them.

The section of Millbrook which lies just north of the yard of the W. H. Sawyer Lumber Company has been covered with a temporary roof. This will prevent the escape of offensive vapors from the sewer into the air in this vicinity, and is undoubtedly much appreciated by the residents.

As has been pointed out several times before, the sewer in Shrewsbury street, opposite East park, for a distance of about 1,000 feet, has settled badly, and should be rebuilt as soon as possible. The sewage carried by this sewer is very foul, and much solid matter is deposited in the depression. This decom poses and gives rise to very offensive odors, which find their way into the air in the immediate neighborhood, and are a source of much annoyance. A portion of this sewer is so badly cracked that braces are set once in four feet to sustain the arch. There is danger of the arch giving way notwithstanding this precaution, and if this should happen in the winter, repairs would be made with difficulty. If it should occur during a freshet considerable damage might be done.

Another menace to the safety of property exists in the condition of Millbrook. While this structure is in as good condition as ever, it is not safe. The bottom is paved with small stones not laid in cement. Large holes are washed out every year at the points where the lateral sewers enter, and these are refilled with stones. In such cases the arch is liable to fall. Should there be a serious break of this kind in time of freshet, when indeed it is most liable to occur, the extent of the damage would be very great.

An illustration of this was furnished this year, when the arch fell in at the corner of School and Union streets. The scour of the discharge from the School street sewer has frequently made large holes in the bed of Millbrook. As a natural result the bedstones upon which the arch rested were undermined until they finally settled, releasing a number of the ring stones. A similar condition exists all along the channel, except where it has a permanent paving. Consequently a break is liable to occur at any time. The bottom of this sewer should be paved with Portland cement concrete as soon as possible.

Aside from these two instances of defective sewers the system is in very good condition.

A classification of the expenditures in the sewer maintenance account is as follows:

MONEY EXPENDED IN DIFFERENT DIVISIONS OF MAINTENANCE.

Total cost of new catch-basins built	$3,901 80
Total cost of repairing old basins, man-holes and sewers	3,860 50
Total cost of cleaning sewers and catch-basins	15,588 05
Total cost of work chargeable to other parties	5,672 40
Rental and purchase of East Worcester street property	20,285 00
Expense of covering Millbrook	675 07
Margaret O'Brien, damages, walling sewer, Bradley street	400 00
Total	$50,382 82

It will be noticed that $30,934.27 was expended for the purchase of additional property on East Worcester street, the covering of Millbrook, damages in the case of Margaret O'Brien vs. City of Worcester, building new catch-basins and doing work at the expense of outside parties, leaving the sum of $19,448.55 as the net cost of repairs, cleaning and strictly maintenance charges. This amounts to $128.06 per mile of sewers, including 2,288 catch-basins.

In considering these figures it should be remembered that the grades of many of the streets are very steep, and that there are hundreds of catch-basins which have to be cleaned after every storm.

CONSTRUCTION.

During the year 6.522 miles of sewers have been constructed and charged to this account. Upon these sewers 151 manholes and 9 catch-basins have been built. The total sewer system now includes 151.086 miles of sewers, 5,807 man-holes, and 2,288 catch-basins.

There have been 475 permits issued during the year for connection with the public sewers. Of these, 341 were for sewage, 98 for surface water, 11 for repairs, and 25 were not used.

Following is a brief schedule of property for which the department is responsible:

Personal property		$68,063 87
Stock on hand		11,359 48
Buildings and machinery, East Worcester street		10,166 60
Land, 1,700 feet on Hammond street		425 00
Land, 18,060 feet on East Worcester street		7,224 00
Land, 33,221 feet on East Worcester street		13,300 00
Total		$110,538 95
Purification Works:		
Land	$54,016 75	
Buildings and machinery	32,925 00	
	$86,941 75	
		86,941 75
Sewer system. including cost of sewers, catch-basins, etc		4,690,384 90
		$4,887,865 60

Considerable advance has been made toward sewering Greendale.

Work on the trunk sewer has been prosecuted continuously since early spring, and during the fall work was being done on several sections at the same time. Before the season has closed it is expected to complete the trunk sewer to a point nearly as far north as Summerhill avenue.

This sewer was originally ordered in West Boylston street as far as Summerhill avenue. Before the work had been completed to Barber's Crossing, however, the owners of the various factory properties petitioned for sewer accommodations in the rear of their buildings along Barber brook, which is at a much lower level than it was contemplated building the trunk sewer in West Boylston street. A large district lies northerly of this property which is too low to drain into the sewer designed for West Boylston street, and it was intended to run another trunk sewer up the valley at some future time to provide for it. On account of the change which will be necessary in the grade of West Boylston street when the railroad crossing is abolished, a trunk sewer in that street, if built, would have to be laid very deep. For these reasons it was decided to change the original route laid out for this sewer to a location along Barber brook, and construct shallow sewers to cover the distance planned for in West Boylston street. It is intended eventually to run this sewer up the valley as far as Brooks street, but it has been built at the present time only to a point about opposite Summerhill avenue. From here it runs through land of the Morgan Spring Co. and across the railroad location into West Boylston street. A shoal sewer connecting with it provides accommodation for territory between there and Fairview terrace. Another sewer connecting with the trunk below Barber's Crossing runs as far as Fairview terrace. In this way both the mills and the property along West Boylston street are provided for, and an outlet secured for the entire low level district at an expense not exceeding that of the first planned route.

An opportunity was offered by the Morgan Spring Co. to run a surface water sewer across their property discharging into Barber brook. As it was contemplated erecting a building over their location in the near future, and as it was necessary to have an outlet into the brook through this property, it was decided to build the surface water drain at once. This consisted of a 39-inch brick sewer, and runs by a direct course from West Boylston street to the brook, and will be the outlet for a large water-shed draining to this point. It will thus be seen that a very substantial beginning has been made towards the sewering of Greendale.

Five miles from this work a force of men has been engaged a large part of the season extending the sewer in Southbridge street from College street to Malvern road. This district has been built up considerably during the last few years, and sewer accommodations were much needed. This sewer is 15 inches in diameter, and is designed to receive no surface water.

The houses on Oleum court have for several years been connected with a private drain connecting with the public sewer in Shrewsbury street. This drain gradually settled on account of the poor foundation and early in the fall completely failed to operate. A public sewer was ordered constructed in October. That there might be no further settlement the sewer was laid on a pile foundation. Borings were taken and it was found that peat extended to a depth of about 18 feet below the surface of the ground. Below this, for a distance of about 40 feet, there was a stratum of very fine sand through which the piles were driven very easily. Below this quicksand was a stratum of coarse, sharp sand, in which the piles readily found a footing. Near Shrewsbury street piles were driven over 70 feet below the surface of the street, and the depth to which it was necessary to drive them gradually decreased as the work approached the hill, so that at the end of the sewer they were driven a little less than 60 feet. The piles were driven in bents of two 22-inch on centres, and the pile bents were 3 feet on centres. They were capped with 6-inch by 6-inch spruce timbers running parallel with the trench.

Spreader blocks 6 inches by 6 inches were driven in between the cap pieces every 6 feet, and close to each spreader a 7-8-inch iron tie rod held the caps together. At each pile a 7-8-inch by 18-inch iron pin was driven through the cap into the end of the pile. A bed of Portland cement concrete was placed over and between the caps. This was brought up around the 12-inch pipe sewer and carried over the top of it. All the piles were spliced, a 40-foot pile being driven first. When this pile was driven to a convenient depth it was squared up, an iron ring just a little smaller than the stick forced on and two iron dowel pins, 7-8 inch by 18-inches, driven half their lengths into the end of the pile. Another pile 20 feet long was then centered on top of the first one, having first been fitted with an iron ring as the first one was, and with a light blow of the hammer the dowels were driven into it. The driving was then continued until the pile had reached a suitable footing, when it was cut off at grade and capped as described. The average penetration with a drop of 16 feet was about 1 1-2 inches, with a hammer weighing 2,200 pounds.

The discharge of sewage into Hermitage brook above Catharine street has caused some complaint in past years. This year a petition for the extension of the sewer from Catharine street to Mt. Vernon street was granted, and a 48-inch sewer has been built. It follows closely the bed of the brook, and receives the waters of the stream as well as the sewage.

For many years much trouble has been experienced by the Street Department in keeping College street in passable condition, owing to the large volume of water running down the hill in time of storm. This year a surface water sewer with the necessary catch-basins has been extended as far as City View street. A sanitary sewer was placed in the same trench. It is expected that the basins built will stop all of the water running to them, and that there will be no more serious washouts.

TABLE IX.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1900.

SURFACE SEWERS—CONSTRUCTION.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.	Cost.	Estimate
Beeching,	Pleasant, northerly,	12	67.0	1		
Berwick,	Pleasant, northerly,	12	307.1	1		
City View,	College, easterly,	12	412.0	2		
		10	187.0			
College,	Extension to City View,	20 Akron	763.9	5		
		18 oval,	336.4			
Dayton place,	Dayton, southerly,	12	178.5	2		
Delaware,	Fremont to New York,	12	377.4	2		
Ellsworth,	Quinsigamond Ave. to Lunelle,	18 oval,	416.3	4	$779 77	$665 00
Fairfield,	Park avenue, northwesterly,	12	546.9	3		
*Gold St. court,	Bradley, southerly,	12	106.0	0		
	RECONSTRUCTED.					
Hackfeld road,	Highland, northerly,	12	531.7	4		
Holland road,	Main, northerly,	12	560.9	5		
New York,	Extension, southeasterly,	12	402.9	2		
Noses,	Pleasant, southerly,	12	693.4	3		
Park avenue,	Tufts to Chandler,	12	549.1	3	968 60	720 00
Pitt,	Cambridge to Sherman,	15	349.6	3	430 58	570 00
Southbridge,	Extension, southerly,	12	69.6	0		
Location,	West Boylston to Weasel brook,	39	220.2	2	1,699.62	2,030 00
		24	48.0			
Taft,	Cambridge to St. John's cemetery,	12	294.2	3		
					$3,878 57	$3,985 00

*This length not to be added in total length for year.

TABLE X.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1900.

SURFACE SEWERS — STATUTES OF 1900.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.
Agricultural,	Highland to Institute road,	30 round	490.1	8
		28 "	271.2	
		18 x 27	305.8	
Agricultural,	Elm, northerly (connections).	34 x 51	113.0	0
Cambridge,	Washburn to Southbridge,	18 oval,	490.1	6
		15	319.7	
D,	Lawrence to Colton,	12	104.1	2
Einhorn road,	Highland to Institute road,	12	803.0	5
Elm,	Merrick to Agricultural,	12	427.0	3
Germain,	Extension, northerly,	12	389.7	4
Hall,	Curve into Institute road,	15	38.5	1
Hudson court,	Hudson, westerly,	12	255.0	2
Institute road,	Agricultural to Hall,	18 x 27	197.0	3
Lawrence,	Kansas to D,	12	396.6	3
Merrick,	Elm, northerly,	12	220.8	1
Millbury,	Quinsigamond avenue, southerly,	15	683.4	8
Millbury,	Millbrook, near gate-house, northerly,	12	334.1	7
		15	385.4	
		12	239.8	
		10	384.1	
Park avenue,	Curve into Chandler,	20 x 30	47.1	1
Park avenue,	Hudson court, northerly,	15 Akron,	377.6	2
Parker,	Connection across Park avenue,	28	77.0	1
Pleasant,	Curve into Park avenue,	12	27.9	1
"	Curve into Russell,	44 x 66	23.0	1
"	Park avenue, westerly,			1
Pond,	Harding to Beach,	18 oval,	343.6	4
Quinsigamond Ave.	Millbury, northerly,	12	136.2	1
Russell,	Connections at Elm and Pleasant,	36 x 54	54.1	0
Schussler road,	Highland to Institute road,	12	633.4	4
*South Crystal,		14 and 15	93.0	
Temple,	Harding to Green,	12	666.7	5
Trowbridge road,	Highland to Institute road,	12	694.0	4
Winter,	Harding to Green,	15	527.9	4

*This length not to be added in total length for year.

TABLE XI.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1900.

SANITARY SEWERS—CONSTRUCTION.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.	Cost.	Estimate
Batchelder,	Pattison, northerly,	8	271.0	3	$340 63	$400 00
Beaver,	Location to Florence,	8	685.7	6	1,255 06	1,880 00
Berwick,	Pleasant, northerly,	8	307.1	1	615 46	940 00
Boardman,	West Boylston to Loring,	8	455.7	3	455 52	325 00
Bond,	Columbus Ave. to Fairmont Ave.	8	238.6	2		
Boylston court,	Jefferson, southerly,	8	191.7	2	323 33	385 00
Carlstad,	Halmstad, southerly,	8	133.6	1	177 31	210 00
City View,	College, easterly,	8	509.0	2		
Coes,	Extension, westerly,	8	176.9	1	1,115 32	(a)
College,	Clay to City View,	8	850.3	3		
Columbus avenue,	Filters to Bond,	8	296.9	1		
Dayton place,	Dayton, southerly,	8	188.2	1	588 90	450 00
Delaware,	Fremont to New York,	8	389.7	2	1,172 71	980 00
Englewood Ave.,	Lisbon to Genoa,	12	330.8	2	1,863 68	1,050 00
Everard,	Vinson, southerly,	8	290.0	2	483 96	412 00
Fairfield,	Park avenue, northwesterly,	8	499.7	3	1,998 74	1,540 00
Fairmont avenue,	Bond to Hamilton,	8	419.7	3		
Fairview terrace,	West Boylston, easterly,	8	896.9	5	930 03	1,440 00
Forbes,	Extension, easterly,	8	217.9	2	236 59	510 00
Fremont,	New York to Delaware,	12	271.3	2		(b)
Genoa,	Englewood Ave. to Circuit Ave.,	8	319.6	3		(c)
Granite,	Extension, southerly,	8	138.7	1	195 03	150 00
Grove,	West Boylston, westerly,	12	601.0	4	1,400 06	1,330 00
Hackfeld road,	Highland, northerly,	8	519.5	3	671 73	740 00
Hermitage brook,	Catharine to Mt. Vernon,	48	624.9	3	4,877 12	4,340 00
Holland road,	Main, northerly,	8	558.9	5		
Huntington Ave.,	West Boylston to Tower,	8	530.1	3	753 36	810 00
Knowlton avenue,	Cambridge, southerly,	8	252.4	2	345 14	320 00
Loring,	Boardman, southerly,	8	348.3	3	767 26	960 00
Midland,	Extension to Elm avenue,	8	381.0	2	551 59	540 00
New York,	Extension, southeasterly,	8	408.7	1	922 60	520 00
Nixon avenue,	Cambridge, southerly,	8	251.6	2	335 87	310 00
Noyes,	Pleasant, southerly,	8	696.2	3	1,404 19	1,890 00
Oleum court,	Shrewsbury, northerly,	12	257.6	2	2,925 16	1,130 00
Orient,	Extension, northerly,	8	630.3	4	2,347 96	1,830 00
Perkins,	Lincoln, easterly,	12	33.4	1		
Location,	Park avenue to Beaver,	8	499.2	3		(d)
Location,	Barber's Crossing,	15	1,838.0	14		
Southbridge,	Extension to Malvern road,	15	2,274.6	14	8,516 61	9,910 00
Strand,	West Boylston, southerly,	10	605.5	4	1,641 05	1,430 00
Taft,	Cambridge to St. John's cemetery,	8	296.0	2	600 35	585 00
Tatman,	Extension, westerly,	8	200.0	1		
Tower,	Huntington Ave. to Hastings Ave.	8	625.0	3	779 73	1,150 00
Vinson,	Hermitage brook, easterly,	18	12.4	12	1,014 68	2,450 00
		15	289.1			
		12	119.0			
West Boylston,	Location, southerly,	8	562.0	3	770 73	700 00
		15	3,524.8			
West Boylston,	Extension to Fairview terrace,	10	102.9	30	1,358 06	1,480 00
		8	736.0			
					$43,735 51	$43,087 00

(a) Work done for Water Department.
(b) Combined with Delaware street.
(c) Combined with Englewood avenue.
(d) Combined with Beaver street.

TABLE XII.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1900.

SANITARY SEWERS — STATUTES OF 1900.

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.
Assonet,	Gold Street court to Gold,	8	447.4	3
Agricultural,	Connection with old sewer to Highland,	12	585.0	5
Bangs court,	Union, westerly,	8	211.3	1
Bartlett,	Franklin to Cherry,	32 x 42	423.0	0
Berkshire,	Hampden to Highland,	8	452.4	2
Bowdoin,	West, easterly,	8	1,070.7	6
Bradley,	Gold to Washington,	8	842.1	6
Bridge,	Front to Manchester,	28 x 38	274.0	4
		26 x 34	270.7	
Cambridge,	Curve at Washington,	32x42 & 24x30	23.9	1
Canal,	Cherry,			1
Cedar,	Sever to Chestnut,	8	2,090.3	13
Cedar,	Sever to Agricultural,	8	764.1	5
Central,	Commercial to Union,	8	240.5	2
Central,	Commercial to Main,	10	366.8	4
Cherry,	Bartlett to Warren,	32 x 42	293.6	1
Cherry,	Warren to Canal,	8	170.7	1
Colton,	Washburn to Southbridge,	8	395.6	4
Commercial,	Curve at North Foster,	24 x 30	25.9	1
Cottage,	Fruit to West,	8	381.8	2
Dayton,	Sever to West,	12	778.0	17
Denny,	Dix to Highland (1 flush tank),	8	455.4	2
Dix,	North Ashland to Harvard,	8	1,121.7	7
Ellsworth,	Extension, easterly to Millbrook,	8	240.4	2
Elm,	Connection across Sever,	8	81.8	1
Everett,	William to Cedar,	8	195.2	2
Foundry,	Vine, easterly,	18	295.2	2
Franklin,	Connection with Vine,	10	44.3	0
Franklin,	Harding, westerly,	8	133.6	1
Fruit,	Elm to Cottage,	8	306.1	3
"	Dayton to Highland,	8	582.7	4
"	Cedar to Elm,	8	231.3	1
Gold Street court,	Bradley to Gold,	8	503.5	4
Gold Street court,	Bradley to Lamartine,	8	239.2	2
Grafton,	Water to Franklin,	40 x 54	680.3	2
Green,	Pond to Franklin,	32 x 42	851.1	1
Green,	Bradley to Harding,	8	89.6	2
Hampden,	Fruit to West,	8	321.9	2
Harding,	Harrison to Franklin,	15	446.2	12
		12	412.0	
		10	329.1	
		8	291.8	
Harrison,	Green to Harding,	15	425.0	5
Highland,	Pink to West (1 flush tank).	8	174.2	1
"	West, westerly (1 flush tank),	8	149.9	0
"	Sever to Agricultural (1 flush tank),	10	437.2	7
		8	468.1	
"	Agricultural to Germain,	12	38.5	6
		10	720 4	
		8	263.0	
Home,	North Ashland to Wesby,	8	433.0	3
Home,	Wachusett to Wesby,	8	236.7	1
Institute road,	Curve into Lee,	8	29.8	0
Institute road,	Curve into Westland,	8	38.5	0
John,	West to Harvard,	12	47.3	12
		10	180.6	
		8	1,335.3	
Kansas,	Cambridge, northerly,	12	669.5	4
Lamartine,	Washington to South Harding,	10	378.4	4
Layard place,	Connection at Central,	6	29.5	1
Lee,	Park avenue to Institute road,	8	839.5	6
Lily,	Pink to North Ashland,	10	280.1	1

TABLE XII. — *Continued.*

STREET.	LOCATION.	Size (inches).	Length (feet).	M. H.
Main,	School to Lincoln Square,	18	251.3	6
		15	702.8	
Manchester,	Bridge to Union. 1 M. H. is sump, on old sewer.	24 x 30	615.2	4
Market,	Union to Main,	8	378.8	3
Marston way,	Curve into Sever,	8	41.7	1
Mechanic,	Bridge, easterly,	8	166.5	2
Merrick,	Pleasant, southerly,	8	309.6	3
Millbury,	Siphon chamber, southerly,	10	664.3	13
		8	1,023.7	
Millbury,	Ballard, northerly,	10	509.6	10
		8	682.5	
North Ashland,	Lily to Highland (1 flush tank),	10	331.7	6
		8	440.5	
" "	Lily to John,	8	108.0	2
" "	Bowdoin to William,	8	100.5	1
North Foster,	Union to Commercial,	24 x 30	384.2	3
Oak,	Cedar to Elm,	8	277.3	2
Park avenue,	Highland to Lee,	8	286.4	2
Pink,	John to Highland,	10	192.6	5
		8	742.7	
Pleasant,	Merrick to Sever,	10	360.5	3
Prescott,	Lincoln square to Lexington,	10	767.3	10
		8	355.9	
School,	Commercial to Main,	18	360.6	3
School,	Commercial to Union. 1 M. H. sump, on old sewer,	12	166.4	2
South Harding,	Lamartine, southerly,	8	397.7	2
*Temple,	Harding, westerly,	10	118.7	0
Thomas,	Commercial to Union,	12	20.9	1
		8	200.4	
Union,	School to Lincoln square,	12	264.6	7
		10	219.7	
		8	368.5	
"	Thomas, southerly,	8	160.8	1
"	Central, southerly,	8	308.0	3
"	Manchester to North Foster,	24 x 30	192.0	2
Vine,	Cherry to Franklin,	10	333.4	
Wachusett,	Dix, southerly,	8	323.9	2
Warren,	Cherry to Front,	32 x 42	288.8	0
Water,	Ledge to Grafton,	40 x 54	442.2	2
Wesby,	Home to John,	8	200.1	1
West,	Dayton, northerly,	8	1,873.2	11
"	Dayton, southerly,	8	316.7	2
"	William, southerly,	8	276.6	2
"	Cedar to Elm,	8	284.0	2
"	Elm to Pleasant,	8	462.3	3
Westland,	Highland to Institute road,	8	1,136.9	6
William,	Extension, easterly,	8	1,266.4	7

*This length not to be added in total length for year.

SEPARATING SYSTEM.

There still seems to be a popular misunderstanding of the scope of the work contemplated for immediate construction in accordance with the plan presented to the Supreme Court in 1897, and to make the subject as clear as possible the following explanation is made, although largely a repetition of statements made in previous reports.

To understand the situation thoroughly it should be remembered that, before any sewers had been built, there was a brook or river of some size running from north to south through the central portion of the city. This was called Mill brook, and was fed largely by the water-shed above Lincoln square, but was contributed to also by numerous small brooks running into it at frequent intervals along its course. The natural outlet for sewers was into this stream and its tributaries, and from time to time the sewers that were built were connected to it. This procedure was authorized by an act of the Legislature passed in 1867, which also gave the city permission to use the stream itself and its tributaries as common sewers, stipulating that they might be improved as was deemed necessary by straightening, walling, and covering, and also providing for the acquiring of certain water privileges.

It was found, when the problem of sewage purification was taken up, that the volume of water to be dealt with consisted not only of the sewage proper, but also of the entire drainage of the watershed contributary to the streams mentioned. This proved a serious obstacle in the way of effective treatment, and it was felt from the first that a separation of this drainage water from the sewage was not only desirable, but necessary.

In 1897, complying with instructions from the Supreme Court, the city submitted to the court a scheme for more effectively preventing the discharge of untreated sewage into the Blackstone river. This plan contemplated the construction of intercepting sewers, which should intercept the sewage before it entered Millbrook. To accomplish this two main intercepters were provided for, one on each side of Millbrook, running northerly from Cambridge street. South of Cambridge street one conduit was designed to receive the sewage from both intercepters. This conduit was to be constructed inside Millbrook, connecting with the outfall sewer at Quinsigamond.

The building of the intercepters comprises all that the board of experts, which was retained to advise the city, recommended doing, at present, upon a sewerage system for diverting the sewage from the natural drainage of the city. But it did advise the gradual change from the present combined system of sewers to the separate system, beginning and continuing this part of the work from time to time as it was found that the amount of sewage being discharged into the river was causing a serious pollution.

In accordance with these suggestions, which constituted the plan filed with the court, detailed designs were worked out by the Engineering Department. It was found that if the conduit was to be constructed inside the sewer south of Cambridge street, the capacity of the latter would be so reduced that it could not be safely relied upon to care for the volume of water then flowing into it in times of heavy showers and freshets.

To relieve this situation, it was planned to build a duplicate system of sewers in South Worcester, and in the section of the city naturally draining into Beaver brook. While this was suggested solely to make room in Millbrook for the sewage conduit, it will be noticed that it is in strict accord with the experts' récommendation for future construction. By following this plan, it was pointed out that the necessary reduction in the watershed contributary to Millbrook below Cambridge street would be obtained, and that, in addition, the benefit accruing from the separation of the surface water of this district from the sewage would be realized at an early date.

It was aso found that the grade determined by the elevation of the main sewer would not admit of connecting the Cambridge street sewers with the intercepter, and consequently it was absolutely necessary to resewer most of the district drained by the Washburn street sewer.

A few other districts were found to be similarly situated, especially those lying between Millbrook and the intercepters. In these sections the original sewers, of course, graded toward Millbrook, and when the intercepters were built new sewers would be required which should reverse the flow of sewage and discharge into them.

From this general review of the work laid out to be done as a part of the separate system, it will be seen that the plan of the experts has been followed scrupulously, and that the work which seemed to be exceeding their recommendations was in reality a part of the detail absolutely necessary to the successful carrying out of their advice.

The work on this system has progressed rapidly during the past year, and is in a satisfactory condition, as it is completed and in working order as far as any work has been done upon it, with the exception of the final connections between the conduit in Millbrook and the siphon chamber at one end, and the outfall sewer at the other. All regulators and special appliances which have been built are now operating, and practically the entire sewage of that portion of the city reached by the intercepters, is being discharged into the new system. This, however, will be without effect on the sewage treated at the purification works so long as the intercepters discharge into Millbrook at Cambridge street, where sewage and surface water mingle and flow together to Quinsigamond. The west main carrier is completed from end to end, and all connections are made with it.

The east intercepter is completed as far as the Grafton street railroad crossing, and connections are made.

The portion not now connected with the new system is that lying between the B. & A. railroad location and Grove street, and situated on the east side of Millbrook. While this district contributes a considerable flow of sewage, it constitutes rather a small fraction of the city.

The work of providing a duplicate system of sewers in the southern and western sections has been entirely completed, and all connections made. No surface water now finds its way into the sanitary system of these districts, except ground-water leakage, of which there is undoubtedly some, especially in the older sewers. All surface water from these districts is discharged directly into Beaver brook and the river at South Worcester. This having been done, there is no reason why the carrier in Millbrook can not be closed at its upper end, which would make the intercepters in the vicinity of Cambridge street complete, with the exception of a few days' work at the outfall when the east carrier is finished. If there is no unforeseen delay, the east carrier should be completed, with all connections made, by the end of the next fiscal year. It will then be possible to treat the sewage without the water from North pond, which amounts to 5,000,000 gallons per day in dry weather.

West Intercepter.

PNEUMATIC TUNNEL IN GREEN STREET.

The pneumatic tunnel through Green street, Bartlett place and Cherry street was described in detail in the report for 1899. At the beginning of the present year about 1,100 feet of this tunnel remained to be lined. This was done during the winter months under the immediate supervision of Mr. Harry L. Dadmun.

In December, 1899, the city was threatened with a serious water famine, and two of the boilers from the power station connected with this work were taken to Coes pond, where a temporary pumping plant was erected by the Water Department. The remaining boilers proved capable of furnishing sufficient power to run the lighting plant, and the compressors to furnish enough air in the tunnel to prevent the infiltration of ground water through the temporary lining while the permanent lining was being put in place.

The boilers loaned the Water Department have been returned, and are being set and piped to furnish power for the pneumatic tunnel to be driven across Washington square during the coming winter.

WARREN, BRIDGE, MANCHESTER, UNION AND NORTH FOSTER STREETS.

This portion of the intercepter which starts at the corner of Franklin and Green streets and ends at the south end of Commercial street, was constructed in tunnel for a distance of 605.37 feet. The description of this tunnel was given in the report for 1899. Having run out of fine sand the tunnelling was stopped and the work continued in open cut. A large quantity of ground water was met and a six-inch centrifugal pump was set up to keep it under control. After pumping for some time the flow decreased so that it was kept down by a four-inch pulsometer pump. The material was very coarse gravel for some distance, changing to a very fine sand. The trench in Warren street was very close to the street line, there being about six feet between the five-story brick block situated at the corner of Warren and Front streets and the side of the trench. As the excavation was twenty feet deep great care was taken to hold the banks so that no settlement could take place.

Careful measurements were taken on the sills of the building before the work was begun, and no change in elevation can be detected, and no new cracks have been detected. This sewer was built to the centre of Front street, at which time the work was stopped for the winter.

In the spring the work was taken up again and pushed as rapidly as possible, although progress was very slow until Foster street was reached.

Between Front and Mechanic streets the depth of excavation was twenty-three feet.

The material was fine sand, and required heavy and careful sheathing and bracing. Sheathing was driven several feet ahead of the work with the aid of steam plank driving machines.

There are brick buildings on both sides of the street through which this section of the intercepter runs, and though the material excavated was of the most treacherous description, no settlements have resulted. Throughout the entire length of the trench much lumber was left in the ground to insure the safety of pipes, conduits and sewers lying near by, as well as to prevent any settlement of the buildings.

At the corner of Bridge and Foster streets the material again changed to a coarse gravel, and it was necessary to run a six-inch centrifugal pump constantly to take care of the water. After several weeks, however, this pump was replaced by a four-inch pulsometer, which kept the water under control without trouble.

It was expected that a very poor foundation for the sewer in Manchester street would be found, because it seemed to be a matter of common knowledge that mud, peat or quicksand was very deep in this locality, and some of the brick buildings are very badly cracked. It was found, however, that a very good gravel bottom could be reached with little difficulty, and much of the distance it was unnecessary to take any special precaution. Toward Union street some peat was found which was all excavated to clay or gravel foundation, and the trench was refil'ed to grade with gravel, carefully puddled. In Manchester street the maximum depth excavated below grade was six feet; in Union street, nine feet, and in North Foster street the deepest excavation was thirteen feet below grade and twenty-three feet below the surface of the street. The work on the School and Main street section having been completed, this section formed the connecting link in the west intercepter, and when the connection was made between North Foster street and Commercial street this carrier was completed and ready for use from end to end.

The intercepter discharges into a siphon chamber at the corner of Quinsigamond avenue and Cambridge street, and runs through Quinsigamond avenue, Lafayette, Washington, Bradley, Green streets, Bartlett place, Cherry, Warren, Bridge, Manchester, Union, North Foster, Commercial, School and Main streets to Lincoln square. It is 2.4 miles long and ranges from a 48-inch round in Quinsigamond avenue to a 15-inch round at Lincoln square.

All the combined sewers entering Millbrook along its course are intercepted as explained under the paragraph on regulators.

SCHOOL AND MAIN STREETS.

This is the last section of the west intercepter. It starts from the end of the section built in Commercial street in 1899, and ends at the north side of Lincoln square. At this point existing sewers from Highland and Grove streets are intercepted. The construction of this sewer was attended by no special difficulties. The excavation was through gravel and hardpan until reaching the vicinity of the Court House, where a small outcropping of ledge was encountered. The trench was nowhere excessively deep, and the small amount of ground water found its way through the underdrain to a lower level at Commercial street, so that continuous pumping was unnecessary, the pulsometer located at the corner of School and Commercial streets being operated only at night, after the work had advanced a short way from the corner. The sewage from the School street sewer as well as that from Highland and Grove streets enters the intercepter through automatic regulators.

RESEWERING BETWEEN MILLBROOK AND INTERCEPTER.

As explained in the general description of the separate system, the streets lying between Millbrook and the west intercepter have been resewered. A trunk sewer was laid in Harrison and Harding streets to Franklin street, and the old sewers in Pond, Winter and Temple streets were connected with it. New surface water drains were constructed in these streets. A part of the way in Harding street it was necessary to lay the new sewer in the sidewalk because there was no room in the roadway for it. This was the case also with the sewer built in Union and Prescott streets.

A sanitary sewer has been built in Millbury street, from Quinsigamond Village to Cambridge street, on the east side. It is in two sections, one draining into the siphon chambers at Cambridge street and the other grading toward Ballard street, and connecting with the siphon which delivers the Ballard street sewage into the gatehouse on the outfall sewer.

A surface sewer has been built on the west side of Millbury street from Quinsigamond avenue to Quinsigamond Village. These two sewers are necessary because sanitary connection cannot be made with Millbrook on the east side, as that portion of the brook is used for surface water, and all the inlets on the west side enter the intercepting conduit, so that surface water cannot be connected with them. It would be very expensive for the owners of the abutting property to cut through the walls of Millbrook above this conduit for their individual surface water drains.

SEPARATE SYSTEM ON THE WEST SIDE.

This duplicate system of sewer construction which was begun in 1897, has been completed this year. It accommodates a section of the city formerly and naturally draining into Beaver brook. The sewers built in this section have all been small, but many of them have been deep, so that plumbing from houses located on lots of land sloping away from the streets could be connected with them without necessitating raising it. Work has been done in nearly every street between Pleasant and Highland streets, and on this account much inconvenience has been experienced by the public. It is a cause for congratulation that this work is now complete. While so much annoyance has been caused, very few complaints have been made by residents affected, and the general disposition to make the best of the troublesome situation has been sincerely appreciated.

The final connections between different sections of the surface water system have been made so that all drainage from the district discharges into Beaver brook, and Millbrook is relieved to that extent in time of high water.

Many times the question of proper flushing of the small sanitary sewers has been raised by parties interested. It is the prevalent impression that the admission of surface water to a sewer is of value in keeping the pipes clean and free from deposit. The reverse of this theory has, however, proven true in this locality. The most of the sediment found in the sewers is caused by deposition of detritus washed in during heavy rains. In most sanitary sewers the grades and volumes of sewage are such that the sewers are self-cleaning. In some cases where the grades are very flat, automatic siphon flush tanks have been attached to the dead ends of the sewers. These, by rapidly discharging a small volume of water, say 300 gallons, once in every twenty-four hours, are much more effective than would be the rain-water which might flush the pipes several times in a few days, and then allow deposits to accumulate until another rain, which might not come for several weeks.

By the automatic daily flushing a very effective cleaning is accomplished with a small amount of water, and the work of purification is not complicated by large quantities of surface water whenever there is rain.

CHANGING HOUSE CONNECTIONS.

Wherever duplicate sewers have been built and new sanitary sewers have been constructed, the old pipes having been turned over for use as surface water drains, it has been necessary to disconnect the pipes leading to the houses from the old sewers and connect them to the new sanitary pipes. In some cases this could be accomplished within a few feet of the sewer, but many times it requires the relaying of the drain for comparatively long distances, in a number of cases even to the pipes leaving the buidings. Much difficulty was experienced in finding the old drains, of which no records have been kept, so that the expense of the change was out of proportion to the actual change required in the original drain. Changes have been made as described in over 1,300 house connections.

EAST INTERCEPTER.

WATER STREET.

This section of the east intercepter was completed from Millbury street to Ledge street in 1899, and was fully described in the report for that year. This work was wholly in tunnel. In 1900 work was begun again upon this section, and was carried on in open trench. A small amount of ledge was encountered, and many boulders, together with hardpan and quicksand. There was considerable water in the trench, and that, together with the hardpan excavated, made the progress rather slow. The street was paved with granite blocks, laid on a concrete, base, and with grouted joints. This, of course, had to be taken up, but the expense of putting it back will not equal the expense of tunnelling.

GRAFTON STREET.

The location of this section of the intercepter was close to the curb on the south side of the street. The material excavated consisted of gravel for the first seven or eight feet in depth, below which it was fine sand, and the natural elevation of the ground water was considerably above the bottom of the trench. On account of these conditions the work was very carefully done, heavy bracing being put in and the plank being driven several feet below grade, and for the most part being left in place. As the grade of the sewer required deeper excavation the further north it extended, it was found difficult to hold the ordinary two-inch sheathing in place at the bottom while it was being driven ahead of the work. It was, therefore, decided to put in three-inch sheathing for the second set. It was practically impossible to drive this by hand, and the driving was wholly done with steam hammers.

The surface of the ground water was about eight feet above the elevation of the bottom of the trench.

Work on this sewer was discontinued at the Boston & Albany Railroad location. The trench at this point was twenty-seven feet six inches deep, and it was decided to construct the rest of this section in tunnel.

REGULATORS.

Frequent mention has been made of the interception of the sewage running in the old sewers. The connections between the intercepters and the old system is through automatic arrangements for regulating the quantity of water flowing from the combined system into the new sewers. The intercepting mains are not large enough to carry very much storm water. When surface water is running in the sewers it is received by the main carriers until such time as they become full, then the gates in the regulators partially close, and the excess of water flows by and into Millbrook. In this way the volume of water finding its way into the intercepters is kept under control.

PURIFICATION.

The first effort to purify the sewage was made in 1890, the plant being started on the 25th day of June. The treatment has continued for over ten years, and from time to time improvements and enlargements have made it possible to accomplish a much larger amount of work, and that of a materially better quality. This has been done at considerably less cost than was possible during the first few years. Table 13 gives the quantities of sewage treated each year since the plant was started. The costs given are strictly maintenance charges, and do not include interest on money invested. They do, however; in several years include cost of work, which was more properly construction than maintenance, but which cannot now be separated because the expense was all charged to one account.

It is interesting to note that the cost per capita in 1891 was $0.32, and in 1900, ten years later, $0.41. The latter figure includes the cost of pressing and disposing of the sludge, while that of 1891 included only the cost of pumping it directly onto adjacent fields, an extremely unsatisfactory method of disposal.

TABLE XIII.

COST OF MAINTAINING SEWAGE DISPOSAL WORKS.

Date.	Amount Treated (Gallons.)	Cost.	Cost per Million Gals.	Population.	Cost per Capita.
1890	391,000,000	$47,919 69	$122 55	84,655	$0 56
1891	1,398,000,000	27,761 95	19 86	87,547	0 32
1892	842,000,000	27,575 24	32 74	90,439	0 30
1893	1,795,000,000	24,103 23	13 43	93,138	0 26
1894	4,562,000,000	25,145 21	5 51	95,982	0 26
1895	5,730,000,000	46,847 46	8 17	98,767	0 47
1896	5,840,000,000	43,264 23	7 41	102,698	0 42
1897	6,205,000,000	69,165 64	11 14	106,629	0 65
1898	6,460,000,000	64,440 83	9 97	110,560	0 58
1899	6,241,000,000	84,694 98	13 57	114,492	0 74
1900	4,781,000,000	50,073 34	10 47	118,421	0 41

NOTE.—The costs for 1895-1899 include considerable money spent on construction, but which cannot be separated from maintenance charges because both items were kept in the same account. This is also true of the figures given for 1890.

There is a prevalent feeling among the citizens that the work at Quinsigamond is largely experimental, and that there is some doubt as to the successful outcome of the effort to sufficiently purify the sewage that it may be discharged into the river without adding to the amount of impurity already carried by the stream. It is true that much experimental work has been done upon the subject of sewage treatment, but there is not the remotest chance of a failure of the general principles adopted to be completely successful in accomplishing a satisfactory purification of the sewage. Experiments are being carried out to ascertain the most practical and economical methods of applying these principles. There are indications that methods which would be adopted to-day would differ materially from those which would have been adopted several years ago. The results of the older methods were just as satisfactory so far as the work was concerned, but the newer plans give promise of greater practicability and economy and contain less objectionable and doubtful features. The older schemes may yet prove the most practical, but it would be very unwise to adopt them without giving the more recent discoveries a careful investigation.

It is not surprising that there is a feeling of doubt expressed when the very large sums of money expended by this department are considered. It is also very natural to attribute these large expenditures directly to the problem of purification. While there is an intimate connection between the separating system and the treatment of the sewage, yet it is not reasonable to condemn the latter because the former is necessary. No scheme has been proposed, by any one familiar with the subject, which would accomplish the results without the separation of the waters of Millbrook from the sewage. There has always been a popular feeling that the sewage should be discharged into tidewater. Were this to be done the very first step to be taken toward its accomplishment would be to separate surface water from the sewage, and to do it much more completely and at vastly greater expense than is believed to be necessary, for the present at least, if the plan for local treatment is retained.

The cost of the separating system to date is $749,069.16, and it will cost about $200,000 to complete the east main carrier.

While this expenditure is in direct compliance with the act prohibiting the discharge of sewage into the Blackstone river, it is made necessary no more by the plan adopted for local treatment than would it be for any other reasonable plan, in fact not one of the many experts who have been engaged, either by the city or by the towns opposing the city to study this problem, has considered any other plan as being reasonable.

The expenditures to date for construction of the purification works is $464,410.45. This considered as capital invested would at 3 1-2 per cent. add $16,254.36 to the annual running expenses. For 1900 this would make the total operating expense $66,327.70 or $0.56 per capita.

This amount adds $0.59 to the tax rate for 1900. While it is unfortunate that any money must be raised for the disposal of the wastes of the city, yet it is one of the necessities of nearly every city, and the amount doesn't seem unreasonable.

The average daily quantity of sewage treated this year is 13.1 million gallons. Of this three million gallons have been treated by filtration after flowing through three of the settling basins to remove as large an amount of the floating matter as possible. Of the effluent from the chemical treatment an average of .66 million gallons daily have been filtered, so that the total amount of effluent from the filter beds running into the river has been 3.66 million gallons per day.

The total cost of running the purification plant has been $51,160.28. This item, however, includes some bills for stock used in 1899, and the amount of coal and lime on hand paid for before December 1, 1900. It does not include discounts retained on contract bill, and which cannot be paid until 1901. The actual net cost of maintenance of this work was $50,073.34.

CHEMICAL PRECIPITATION.

No material changes have been made during the year in the method of chemical treatment. Lime alone is added to the sewage, and this, together with the iron salts in the sewage, has produced a very satisfactory effluent. The results of the chemical treatment are shown in Table 14, the monthly averages of the daily analysis being given.

TABLE XIV.

RESULTS OF THE CHEMICAL PRECIPITATION OF THE SEWAGE.

Monthly Averages of Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals.
	Free.	ALBUMINOID. Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.		
Sewage, December, 1899	2.266	.766	.384	.382	9.62	6.35	8.53	8.1
Effluent, " "	1.765	.335	.332	.003	4.92	4.92	8.62	
Per cent. removed	22.11	56.27	13.54	99.15	48.85	22.52	-1.05	
Sewage, January, 1900	1.589	.539	.262	.277	7.61	6.59	7.89	9.0
Effluent, " "	1.246	.239	.234	.005	5.07	5.07	8.03	
Per cent. removed	21.58	55.65	10.69	98.19	33.37	23.06	-1.77	
Sewage, February, 1900	1.100	.544	.269	.275	7.82	4.48	5.24	6.6
Effluent, " "	.806	.231	.222	.009	3.84	3.84	5.20	
Per cent. removed	26.73	56.43	17.47	96.67	50.85	14.29	0.76	
Sewage, March, 1900	.639	.403	.172	.231	4.87	3.13	4.70	7.7
Effluent, " "	.596	.177	.168	.009	2.39	2.39	4.53	
Per cent. removed	6.73	56.08	.233	96.12	50.93	23.64	3.62	
Sewage, April, 1900	.905	.507	.265	.242	6.02	3.34	5.48	10.4
Effluent, " "	.795	.251	.245	.006	3.13	3.13	5.40	
Per cent. removed	12.15	50.49	7.55	97.52	48.00	6.29	1.46	
Sewage, May, 1900	.775	.385	.202	.183	5.55	3.18	5.28	11.0
Effluent, " "	.750	.173	.170	.003	2.72	2.72	5.22	
Per cent. removed	3.23	55.05	15.84	98.36	50.99	14.45	1.14	
Sewage, June, 1900	.906	.456	.238	.218	5.84	3.32	6.25	10.3
Effluent, " "	1.006	.231	.213	.018	2.96	2.96	6.45	
Per cent. removed	-11.04	49.34	10.50	91.73	49.32	10.84	-3.20	
Sewage, July, 1900	1.538	.559	.309	.250	7.20	4.38	8.08	12.2
Effluent, " "	1.469	.328	.281	.047	3.77	3.77	8.22	
Per cent. removed	4.49	41.32	9.06	81.21	47.64	13.93	-1.73	
Sewage, August, 1900	1.331	.465	.202	.263	7.27	4.94	7.63	11.8
Effluent, " "	1.238	.258	.249	.009	3.42	3.42	7.98	
Per cent. removed	6.99	44.51	-23.27	96.56	52.97	30.77	-4.59	
Sewage, September, 1900	1.344	.608	.220	.388	7.75	5.49	7.60	11.8
Effluent, " "	1.281	.286	.272	.014	3.95	3.95	7.65	
Per cent. removed	4.69	52.97	-23.60	96.40	49.00	28.05	-0.66	
Sewage, October, 1900	1.655	.698	.222	.476	8.81	6.78	6.46	12.4
Effluent, " "	1.445	.296	.288	.008	3.65	3.65	7.02	
Per cent. removed	12.69	57.58	-29.73	98.32	58.56	46.16	-8.67	
Sewage, November, 1900	1.394	.700	.214	.486	7.87	5.62	6.10	10.1
Effluent, " "	1.300	.315	.305	.010	4.13	4.13	5.92	
Per cent. removed	6.74	55.00	-42.52	97.95	47.52	26.52	2.95	
Sewage for year ending Dec. 1, 1900	1.292	.551	.244	.306	7.18	4.82	6.64	10.1
Effluent " " " "	1.137	.258	.247	.011	3.65	3.65	6.70	
Per cent. removed	11.99	53.18	-1.23	96.40	49.17	24.28	-0.90	

NOTE.—Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of the sampling. Effluent samples consist of twenty-four portions taken hourly. The figures for average flow per day represent sewage chemically treated.

TABLE XV.

RESULTS OF FILTRATION OF THE SEWAGE.

Monthly Averages of Analyses of Sewage and Filtrate.

(Parts per 100,000.)

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED		Chlorine.	Average Flow per Day in Mil. Gals.
	Free.	ALBUMINOID.						
		Total.	Dis-solved.	Sus-pended.	Un-filtered.	Filtered.		
Sewage, December, 1899....................	1.630	.647	.323	.324	8.65	7.00	8.23	2.3
Effluent, " "	1.827	.052	.052	.000	2.10	2.10	7.97	
Per cent. removed..............	-12.09	91.96	83.90	100.00	75.71	70.00	3.16	
Sewage, January, 1900....................	1.415	.538	.258	.280	9.55	7.42	8.42	3.7
Effluent, " "	1.677	.038	.038	.000	2.39	2.39	8.14	
Per cent. removed..............	-1.85	92.94	85.27	100.00	74.98	67.79	3.33	
Sewage, February, 1900....................	.867	.392	.183	.209	5.32	3.17	5.23	3.8
Effluent, " "	1.108	.058	.058	.000	1.24	1.24	5.17	
Per cent. removed..............	-27.80	85.19	68.29	100.00	76.67	60.88	1.15	
Sewage, March, 1900....................	.590	.258	.145	.113	3.23	2.58	3.98	3.6
Effluent, " "	.910	.046	.046	.000	0.41	0.41	3.65	
Per cent. removed..............	-54.23	82.17	68.26	100.00	87.30	84.12	8.29	
Sewage, April, 1900....................	.862	.257	.155	.102	4.04	3.34	4.91	4.3
Effluent, " "	1.391	.030	.030	.000	0.80	0 80	4.95	
Per cent. removed..............	-61.38	88.33	80.65	100.00	80.19	76.05	-0.81	
Sewage, May, 1900....................	1.019	.279	.143	.136	4.53	3.77	5.58	4.3
Effluent, " "	1.340	.043	.043	.000	0.68	0.68	5.11	
Per cent. removed..............	-31.52	84.59	69.93	100.00	85.00	81.98	8.42	
Sewage, June, 1900....................	1.581	.694	.313	.381	6.60	5.43	7.25	3.7
Effluent, " "	2.486	.092	.092	.000	1.81	1.81	6.32	
Per cent. removed..............	-36.39	86.74	70.62	100.00	72.57	66.74	12.83	
Sewage, July, 1900....................	2.381	.686	.269	.417	8.03	4.46	9.19	1.0
Effluent, " "	4.011	.110	.110	.000	1.18	1.18	8.79	
Per cent. removed..............	-40.39	83.97	59.10	100.00	85.31	73.55	4 04	
Sewage, August, 1900....................	2.155	.426	.213	.218	6.26	3.74	9.42	2.5
Effluent, " "	2.544	.089	.089	.000	0.67	0.67	9.08	
Per cent. removed..............	-15.29	79.11	58.21	100.00	89.30	82.08	3.61	
Sewage, September, 1900....................	2.347	.740	.220	.520	8.13	4.96	8.96	3.8
Effluent, " "	2.205	.100	.100	.000	0.65	0.65	8.63	
Per cent. removed..............	6.05	86.50	54.55	100.00	92.00	86.90	3.68	
Sewage, October, 1900....................	2.188	.719	.249	.470	7.22	4.73	7.78	1.7
Effluent, " "	2.265	.090	.090	.000	0.95	0.95	7.90	
Per cent. removed..............	-3.16	87.50	63.86	100.00	86.86	79.91	-1.54	
Sewage, November, 1900....................	1.900	.545	.263	.282	6.70	5.32	7.06	2.8
Effluent, " "	2.390	.077	.077	.000	0.84	0.84	6.89	
Per cent. removed..............	-25.78	85.86	70.71	100.00	87.44	84.24	2.41	
Sewage for year ending Dec. 1, 1900....	1.624	.447	.226	.221	6.32	4.53	7.11	3.0
Effluent " " " "	1.892	.065	.065	.000	1.17	1.17	6.80	
Per cent. removed..............	-16.50	85.47	71.24	100.00	81.49	74.16	4.36	

NOTE.—The figures for average flow per day represent sewage treated on filter beds.

TABLE XVI.

RESULTS OF CHEMICAL PRECIPITATION AND FILTRATION OF THE SEWAGE.

Monthly Averages of Analyses of Sewage and Effluent from Chemical Precipitation and Filtration Combined.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average flow per Day in Mil. Gals.
	Free.	ALBUMINOID.						
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.		
Sewage, December, 1899	2.122	.740	.370	.370	9.41	6.43	8.46	10.4
Effluent, " "	1.779	.273	.270	.003	4.30	4.30	8.48	
Per cent. removed	16.16	63.11	27.03	99.19	53.07	33.13	-0.23	
Sewage, January, 1900	1.538	.547	.261	.286	8.19	6.83	8.05	12.7
Effluent, " "	1.371	.181	.177	.004	4.29	4.29	8.06	
Per cent. removed	11.11	66.91	32.19	98.58	47.62	31.19	-0.12	
Sewage, February, 1900	1.015	.488	.238	.250	6.59	4.00	5.23	10.4
Effluent, " "	.916	.169	.159	.010	2.89	2.89	5.19	
Per cent. removed	9.76	65.37	33.19	96.01	56.14	27.74	0.76	
Sewage, March, 1900	1.207	.357	.163	.194	4.35	2.95	4.47	11.3
Effluent, " "	.696	.135	.130	.005	1.76	1.76	4.24	
Per cent. removed	42.35	62.19	20.24	97.43	59.54	40.33	5.15	
Sewage, April, 1900	.892	.434	.233	.201	5.44	3.34	5.31	14.7
Effluent, " "	.969	.186	.182	.004	2.45	2.45	5.27	
Per cent. removed	-8.63	57.15	21.89	98.02	54.96	26.65	0.75	
Sewage, May, 1900	.830	.355	.184	.171	5.10	2.80	5.36	15.3
Effluent, " "	.915	.137	.134	.003	2.15	2.15	5.19	
Per cent. removed	-10.24	61.42	27.17	98.24	57.84	23.21	3.18	
Sewage, June, 1900	1.323	.519	.258	.261	6.04	2.87	6.51	14.0
Effluent, " "	1.397	.194	.181	.013	2.66	2.66	6.31	
Per cent. removed	-5.74	62.62	29.85	95.04	55.97	7.32	3.07	
Sewage, July, 1900	1.601	.569	.306	.263	7.26	4.38	8.16	13.2
Effluent, " "	1.662	.312	.268	.044	2.86	2.86	8.26	
Per cent. removed	-3.80	47.30	12.41	83.26	60.61	34.69	-1.22	
Sewage, August, 1900	1.542	.458	.204	.254	7.92	4.73	7.94	14.3
Effluent, " "	1.467	.228	.222	.006	2.94	2.94	8.18	
Per cent. removed	4.86	50.21	-8.11	97.25	62.88	37.84	-3.02	
Sewage, September, 1900	1.697	.684	.235	.249	8.38	5.72	8.47	14.6
Effluent, " "	1.609	.257	.246	.011	3.36	3.36	8.43	
Per cent. removed	5.19	62.41	-4.68	95.59	59.91	41.26	0.47	
Sewage, October, 1900	1.489	.700	.225	.475	8.62	6.53	7.22	14.1
Effluent, " "	1.547	.271	.264	.007	3.32	3.32	7.43	
Per cent. removed	-3.89	61.30	-17.34	98.51	61.49	49.16	-2.91	
Sewage, November, 1900	1.505	.666	.225	.441	7.62	5.55	6.31	12.9
Effluent, " "	1.537	.263	.256	.007	3.42	3.42	6.13	
Per cent. removed	-2.13	60.50	-13.78	98.42	55.11	38.38	2.85	
Sewage for year ending Dec. 1, 1900	1.368	.527	.240	.287	6.99	4.75	6.78	13.1
Effluent, " " " "	1.309	.214	.205	.009	3.08	3.08	6.72	
Per cent. removed	4.17	59.39	15.92	96.85	55.94	35.16	0.89	

NOTE.—The figures for average flow per day represent sewage treated both chemically and filter beds.

Tables 17 and 18 show the amount of organic matter removed by the process during several years. The results of the treatment this year compare very closely with those of former years. The chemical treatment has required the use of 1,230 pounds of lime per million gallons of sewage treated.

The net cost of the chemical treatment has been $19,232.15, which would make the cost per million gallons treated $5.22. To this should be added the cost per million gallons sewage treated for disposing of the sludge—$6.48, making a total of $11.69.

SLUDGE DISPOSAL.

The method and process of disposing of the sludge from the chemical treatment have been more satisfactory than in any previous year.

The total amount of sludge pumped from the settling basins was 41.5 million gallons, of which only two million gallons were run onto the sludge beds, and this in cold weather. These two million gallons of sludge not pressed were mostly removed from crude sewage without chemicals, the effluent being run onto the filter beds.

Table 19 gives some of the more interesting statistics in connection with this work. It will be noticed that the cost of pressing has been reduced from $4.64 in 1899 to $3.15 per ton of solids.

The reduction in cost of sludge pressing in 1900 over that of last year was nearly 20 per cent.

The pressed sludge-cake has been carried to a piece of land leased for the purpose and used for filling. This makes a final disposition of this material, and there is room enough to last for several years.

The large accumulations of sludge on the land leased from Mr. John L. Willard should be disposed of, and the ground under it got into shape to give back to the owner. There is no reason for leaving it longer in its present unsightly and unproductive condition, except the fact that sufficient appropriations are not made to cover the expense of removing the sludge.

TABLE XVII.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE.

DESCRIPTION.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Total amount (by evaporation),	50.88	49.85						
Amount in suspension (by evaporation),	90.67	94.45				-		
Total amount (by albuminoid ammonia),	48.49	50.79	51.68	58.92	53.02	51.89	58.78	58.18
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11	92.09	98.46	99.62	96.58	96.40
Total amount (by oxygen consumed),	53.65	48.84	54.85	51.62	52.00	48.89	51.78	49.17
Amount in suspension (by oxygen consumed),	80.85	81.08	78.01					

NOTE. Large quantities of sulphate of iron are present in the sewage, which make the determinations for oxygen consumed somewhat unreliable.

TABLE XVIII.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE BY SEASONS.

DESCRIPTION.	DECEMBER TO JULY.							JULY TO DECEMBER.							
	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Total amount (by evaporation),	42.76	—	—	—	—	—	—	50.88	55.02	—	—	—	—	—	—
Amount in suspension (by evaporation),	93.08	—	—	—	—	—	—	90.67	95.76	—	—	—	—	—	—
Total amount (by albuminoid ammonia),	46.63	49.69	52 00	48.91	48.67	49.81	54.48	48.49	53.78	52.93	56.10	57.14	54.86	57.06	51.56
Amount in suspension (by albuminoid ammonia),	83.26	91.73	91.45	92.19	93.55	94.16	96.85	76.67	94.36	90.75	93.35	94.30	91.58	96.56	95.76
Total amount (by oxygen consumed),	37.11	46.92	50.78	48.84	46.20	49.85	46.49	33.65	50.23	61.08	53.15	55.46	50.84	53.31	51.92
Amount in suspension (by oxygen consumed),	89.27	82.95	—	—	—	—	—	80.85	92.42	72.91	—	—	—	—	—

TABLE XIX.

RESULTS OF SLUDGE PRESSING.

MONTHS.	SLUDGE PUMPED (MIL. GALS.)				TONS SOLIDS.			TONS CAKE.						
	From Settling Basins.	To Filter Presses.	To Sludge Beds.	Per Cent. Solids in Wet Sludge.	TOTAL.	In Pressed Cake.	On Sludge Beds.	TOTAL.	Pressed.	Sludge on Beds.	Per Cent. Solids in Cake.	Pounds of Lime Added to Sludge.	Cost of Operation.	Cost per Ton of Solids.
December,	4.653	3.993	0.660	3.27	634	544	90	2,305	1,975	330	27.5	75,800	$3,502 38	$6 44
January,	3.526	2.973	0.553	3.70	557	470	87	1,939	1,637	302	28.7	62,400	3,195 48	6 79
February,	1.747	1.605	0.142	5.00	364	334	30	1,268	1,006	262	28.7	39,650	1,506 30	4 51
March,	1.668	1.550	0.118	6.30	438	407	31	1,307	1,214	93	33.5	46,750	1,482 11	3 64
April,	2.530	2.443	0.087	5.33	562	542	20	2,081	1,823	258	27.0	62,000	1,677 09	3 09
May,	3.264	2.805	0.459	5.02	683	587	96	2,322	1,923	399	29.4	95,000	1,569 66	2 67
June,	3.092	3.092		5.16	665	665	- -	1,991	1,991		33.4	85,500	1,218 96	1 83
July,	4.828	4.828	-	4.37	878	878		3,118	3,118		28.3	57,900	2,235 20	2 55
August,	4.713	4.718	-	4.26	837	837		2,978	2,978		28.2	40,500	1,821 28	2 18
September,	4.232	4.232	- —	3.91	690	690		2,654	2,654		26.0	88,500	2,095 58	3 04
October,	4.667	4.667	- —	4.34	849	849		3,391	3,391		25.0	110,900	2,595 35	3 06
November,	2.591	2.591		4.59	496	496		1,947	1,947		25.5	66,500	2,033 88	4 10
Total,	41.506	39.487	2.019	4.42	7,653	7,299	354	27,286	25,647	1680	28.0	830,400	$24,938 31	$3 42

TABLE XX.

AVERAGES OF WEEKLY ANALYSES OF WATER FROM THE BLACKSTONE RIVER

FROM DECEMBER, 1899, TO JULY, 1900: JULY, 1900, TO DECEMBER, 1900, AND FROM DECEMBER, 1899, TO DECEMBER, 1900.

(Parts per 100,000.)

WHERE TAKEN.	DATE OF COLLECTION.	Free Ammonia.	Total Albuminoid Ammonia.	NITROGEN AS		Total Oxygen Consumed.	Chlorine.
				Nitrates	Nitrites.		
Am. Steel & Wire Co. pond....	Dec. 1, 1899, to July 1, 1900.. ...	.019	.039	.028	.0013	0.89	0.61
" " " " "	July 1, 1900, to Dec. 1, 1900......	.046	.064	.033	.0020	1.00	0.81
" " " " "	Dec. 1, 1899, to Dec. 1, 1900......	.030	.050	.030	.0016	0.94	0.70
Bridge	Dec. 1, 1899, to July 1, 1900......	.232	.103	.029	.0030	1.63	1.73
"	July 1, 1900, to Dec. 1, 1900......	.279	.084	.030	.0027	1.35	2.10
"	Dec. 1, 1899, to Dec. 1, 1900......	.195	.095	.030	.0029	1.51	1.89
Swamp	Dec. 1, 1899, to July 1, 1900.....	.328	.143	.046	.0072	1.86	2,02
"	July 1, 1900, to Dec. 1, 1900......	.748	.159	.041	.0133	2.02	4.78
"	Dec. 1, 1899, to Dec. 1, 1900......	.509	.150	.044	.0098	1.93	3.21
Morse pond	Dec. 1, 1899, to July 1, 1900.....	.494	.130	.037	.0117	1 31	3.14
" "	July 1, 1900, to Dec. 1, 1900	.881	.112	.023	.0049	1.34	4.90
" "	Dec. 1, 1899, to Dec. 1, 1900......	.660	.121	.031	.0088	1.32	3.88
Aldrich pond	Dec. 1, 1899, to July 1, 1900......	.358	.087	.030	.0117	0.93	2.35
" "	July 1, 1900, to Dec. 1, 1900......	.724	.098	.024	.0034	1.06	3.62
" "	Dec. 1, 1899, to Dec. 1, 1900......	.513	.092	.027	.0082	0.98	2.88

TABLE XXI.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1900 INCLUSIVE.

	TOTAL ALBUMINOID AMMONIA. (Parts per 100,000.)								TOTAL OXYGEN CONSUMED. (Parts per 100,000.)							
	1893	1894	1895	1896	1897	1898	1899	1900	1893	1894	1895	1896	1897	1898	1899	1900
AM. STEEL & WIRE CO.'S POND																
December to July	——	.023	.032	.025	.022	.024	.027	.039	——	0.74	0.75	0.64	0.59	0.48	0.78	0.89
July to December	.052	.054	.050	.042	.037	.039	.085	.064	1.21	0.87	1.14	0.64	0.67	0.77	1.42	1.00
Average for year	.047	.037	.039	.032	.028	.030	.051	.050	1.03	0.79	0.90	0.64	0.62	0.60	1.01	0.94
BLACKSTONE RIVER, BRIDGE.																
December to July	——	.047	.050	.047	.037	.047	.076	.103	——	0.95	0.96	0.72	0.74	0.88	1.08	1.63
July to December	.085	.062	.056	.060	.048	.071	.070	.084	1.40	0.95	1.05	0.76	1.08	1.09	1.44	1.35
Average for year	.103	.053	.052	.053	.042	.057	.073	.095	1.51	0.95	1.00	0.74	0.88	0.96	1.23	1.51
BLACKSTONE RIVER, SWAMP.																
December to July	——	.129	.109	.096	.085	.115	.110	.143	——	1.21	1.30	0.80	0.89	1.02	1.03	1.86
July to December	.377	.178	.139	.150	.127	.105	.135	.159	2.41	1.60	1.24	1.23	1.24	1.16	1.55	2.02
Average for year	.282	.150	.122	.118	.103	.111	.114	.150	2.12	1.36	1.27	0.99	1.04	1.08	1.24	1.93
MORSE'S POND.																
December to July	——	.108	.093	.097	.082	.067	.081	.130	——	1.17	1.15	0.94	0.92	0.65	1.01	1.31
July to December	.211	.157	.157	.141	.119	.121	.129	.112	1.37	1.41	1.24	1.06	1.07	1.12	1.54	1.34
Average for year	.175	.129	.120	.115	.098	.089	.100	.121	1.43	1.27	1.19	1.00	0.98	0.84	1.20	1.32
ALDRICH'S POND.																
December to July	——	.101	.082	.088	.074	.061	.075	.087	——	1.12	0.95	0.90	0.79	0.87	0.75	0.93
July to December	.172	.151	.132	.152	.108	.168	.083	.098	1.18	1.27	1.08	0.89	0.85	0.86	1.48	1.06
Average for year	.135	.122	.112	.106	.089	.064	.078	.092	1.09	1.18	1.01	0.90	0.81	0.87	1.05	0.98

CONDITION OF BLACKSTONE RIVER BELOW THE SEWAGE PRECIPITATION WORKS.

FROM STATE BOARD OF HEALTH.

(Parts per 100,000.)

MONTHS.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dis-solved.	Sus-pended.				
June—November, 1887........	0.91	......	....	.2686	.1741	......	......	1.35	.0160	.....	...
" " 1888.........	0.76	......	....	.2658	.1112	.0557	.0555	1.50	.0382	.0041	..
" " 1889.........	0.86	.....	...	.3980	.1430	.0772	.0658	1.32	.0177	.0026	...
" " 1890....... ..	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891.........	1.05	22.25	6.60	.6367	.1506	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892..	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.18	.0137	.0050	10.3
" " 1893.........	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894.........	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895...	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896.........	0.30	26.03	6.53	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897.........	0.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898	0.23	25.63	6.73	.3064	.0868	.0560	.0308	1.55	.0132	.0119	9.2
" " 1899.	0.14	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108	.0068	16.1
" " 1900.........	0.22	24.57	4 48	.4430	.1249	.0621	.0628	2.13	.0110	.0145	7.3

FILTER BEDS.

The fourteen filter beds built in 1899 have been in operation throughout the year, and have given very good results. Table 15 gives results of analyses of sewage and effluent from this part of the plant.

An average of 3.66 million gallons of water have been turned onto the filters. Two beds have been used for filtering chemical effluent.

They have received an average of 330,000 gallons per acre per day, and have given very satisfactory results. One new filter has received sewage from the septic tank, and the other eleven have received sewage. Before being run onto the filters the sewage has been allowed to flow through three of the settling basins, each receiving its proportional part. The current through the tanks has been so rapid that the precipitation of solids was not as complete as was desired. It was impossible, however, to devote more basins to this work and maintain the efficiency of the other treatment.

The effluent from the filters has shown a fairly good degree of purification, although the nitrification has been low.

The cost of filtering the sewage has been $6.36 per million gallons, not including the cost of disposing of the sludge removed by subsidence.

SEPTIC TREATMENT.

Much study has been given the action of bacteria in the purification of sewage. The process in which the germs are the important factor is very interesting, and appears of the utmost importance in the disposing of sewage.

Decomposition is the first step in the process. It is brought about by certain species of bacteria. They thrive best where they do not come in contact with any oxygen, although they do not refuse to work in its presence.

Having undergone a certain amount of decomposition the water, now laden with the simpler substances, is subjected to the action of another species of germs by which the organic substances are transformed into inorganic and non-putrescible compounds.

When this result is obtained in a filter there are no sharp division lines between the different stages of the process. It has been proven, however, that a better result can be obtained by isolating the different species and giving to each the kind of work to do for which it is best adapted. This prevents the hindrance of the one by the conditions required by the other, which cannot be avoided when both are in close contact.

To accomplish such a result it has been suggested that the first, or destructive stage be carried on in a tank or cesspool. In such a procedure the sewage flows slowly through a tank, so slowly that it decomposes while in the tank. The solid matter settles to the bottom, where more or less of it decomposes or is dissolved by the water. Large quantities of gas are generated by the putrefactive process, and this being held in the sludge frequently causes it to float, often forming a thick scum over the entire surface of the tank.

In the month of May one of the basins at the purification works was put into operation as a septic tank. Sewage at the rate of 300,000 gallons a day, one filling of the tank, was allowed to flow slowly through it. This has been continued to date, and there is substantially no more sludge in the basin than there was six weeks after it was started. Some of the time there has been a scum on the surface of the water, but a heavy shower or a high wind will liberate the gas, and the floating matter settles to the bottom again.

The effluent from the basin has at all times been very dark colored, and has contained very fine suspended matter. The suspended matter observed in the fresh sewage does not appear in the effluent.

Analysis of the effluent shows that much organic matter has been decomposed.

The odor arising from the effluent, as well as from the tank itself, is offensive in the extreme. When the filters receiving this water are wet, the odor from them is very marked. A subject for further investigation is here presented, and if it is found impossible to prevent these disagreeable evidences of putrefaction, the adoption of the scheme on a large scale will be a subject for serious consideration.

The gas generated from these decomposing substances is

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118837

ANNUAL REPORT

OF THE

PERINTENDENT OF SEWERS,

OF THE

CITY OF WORCESTER,

FOR THE

YEAR ENDING NOVEMBER 30, 1901.

Worcester, Mass.:
PRESS OF F. S. BLANCHARD & CO.,
[illegible] FRONT STREET.
1902.

ANNUAL REPORT

10

OF THE

SUPERINTENDENT OF SEWERS,

OF THE

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FOR THE

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Worcester Mass.:
PRESS OF F. S. BLANCHARD & CO.,
34 FRONT STREET.
1902.

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ERRATA.

Table VIII—*Page 15.*

Total for December = 2.05 instead of 1.82.
Insert May 1 = .02.
" May 2 = .23.
" May 3 = .12.
" July 8 = .07.
" July 12 = 1.00.
Make total for May 4.68.
Make total for July 2.87.
Grand total = 34.97.

Table IX—*Page 16.*

January 11 and 12, 0.69 instead of 0.89, and .03 instead of .04.
April 27 and 28, 0.78 instead of .91, and .05 instead of .06.
April 8, 9 and 10, = .12 (total precipitation). Insert.
March 16 and 17 instead of March 16, and .08 instead of .02.
December 3, 4 and 5, 1.57 instead of 1.40.
August 7, 1.20 instead of 1.10.

Page 29—*Line 2.*

Instead of $44,352.82, read $43,773.99.

To the Honorable City Council of the City of Worcester.

In compliance with Section 21, Chapter 34, of the City Ordinances, the following report of the work and the condition of the Sewer Department for the fiscal year of 1901 is prepared.

Respectfully submitted,

HARRISON P. EDDY,

Superintendent of Sewers.

Office of the Sewer Department, December 15, 1901.

MEMBERS OF THE COMMITTEE ON SEWERS, 1901.

Alderman LOUIS J. KENDALL, Chairman,
Alderman EDWARD J. MCMAHON,
Alderman JOHN W. MITCHELL,
Councilman NELSON H. DAVIS,
Councilman GEORGE H. NUTT,
Councilman JAMES P. CROSBY,
Councilman THOMAS F. HARNEY.

REPORT OF THE SUPERINTENDENT OF SEWERS.

A large amount of work has been done by this department during the year just ended. While the number of men employed has been smaller than during the year previous, the work has been fully as heavy and difficult.

From December 1 to April 1 the average number of men employed was 168, and the minimum number for any one week was 107. From April 1 to the end of the year the number of employees averaged 366, with a maximum of 462, during the week ending June 21. The minimum rate of wages for able-bodied men has been $1.75 per day of eight hours. The length of the working day was limited, by popular acceptance of the statute, to eight hours at the election in December, 1900. This change has had a very material effect upon the cost of the work this year. As the major part of the excavation was dependent upon machine work, it was impossible for the men to accomplish any more than eight-ninths as much work as formerly, because the machines had always operated at as high a speed as posible.

Most of the work done has been on the separating system, and has been very deep, much of it between twenty and thirty feet below the surface of the streets. Excavations have been made through gravel, hardpan, quicksand and ledge. Two short tunnels have been driven, one through quicksand, under air pressure, and one through rock.

The financial statement is presented in Table I, which shows appropriations and revenues available for the use of the department, amounting to $400,728.50, of which $374,276.63 has been expended.

TABLE I.

SUMMARY OF FINANCIAL RESOURCES FOR 1901.

	Maintenance.	Construction.	Purification.	Statutes of 1900.
Balance Dec. 1, 1900	$748 02	$1 78	$ 24	$26,520 39
Appropriation	19,000 00*	30,000 00	41,000 00	200,000 00
Assessments	....	36,231 40	....	....
Revenue	3,158 09	41,250 76	1,540 05	1,277 77
Total	22,906 11	107,483 94	42,540 29	227,798 16
Total expended	22,888 78	103,834 74	42,540 03	205,013 08
Balance Dec. 1, 1901	17 33	3.649 20	26	22,785 08
Amounts expended for bills accrued before Dec. 1, 1900	14 75	5,606 31	1,212 38	633 55
Amounts of bills accrued during fiscal year still unpaid	458 80	1,084 12	2,446 34	32 50
True costs of work done during fiscal year	23.332 83	99,312 55	43,773 99	204,412 03

*Of this amount $2,000 was taken from license money.

The revenue, as credited to the account of construction, arises largely from the system employed for providing tools and supplies. For this purpose a shop-account is kept, and all supplies are charged to this account until used. In addition to this, the cost of delivery and of carpenter and machine work done is charged to this account. Each month bills are made out in favor of the shop, and are charged to the work upon which the materials are used. By this method, supplies can be purchased at much better prices than when they are obtained in small quantities for individual requirements.

Following is a schedule of the lengths of sewers built under

The accounts of construction and separation, together with the number of manholes and catch-basins:

GENERAL CONSTRUCTION.

Sewers	2.987	miles.
Surface water drains	.922	"
Total	3.909	"

SEPARATING SYSTEM.

Sewers	3.282	miles.
Surface water drains	.186	"
Total	3.468	"

BRICK SEWERS.

Sewers	1.657	miles.
Surface water drains	.168	"
Total	1.825	"

Total miles of sewers	7.377
Total number of manholes built	257
Total number of catch-basins built	136

The statements made in the last report regarding needed improvements at the headquarters on East Worcester street are just as true, and should be made fully as urgent.

The machinery and tools owned by the department are for the most part in good condition. One or two new hoisting-engines might be purchased, and would add materially to the equipment.

The excavating machines owned by the city have been in use throughout the season, and for several months two were hired from the Carson-Trench Machine Company. Two or three hoisting-engines have been hired during the busy season.

A 36-inch x 36-inch x 10-foot metal planer and a 22-inch x 13-foot engine lathe have been added to the equipment of the machine shop.

The stock used in the construction of sewers and the treatment of sewage has been very similar to that used last year. Table II gives the quantities purchased, and the contract prices paid for the same during the last four years.

TABLE II.

MATERIALS PURCHASED BY THE SEWER DEPARTMENT.

MATERIAL.	CONTRACTOR.	PRICE PAID.				APPROXIMATE AMOUNTS PURCHASED.			
		1898.	1899.	1900.	1901.	1898.	1899.	1900.	1901.
Sand,	Emory S. Streeter,	$0 75	$0 875	$1 05	$1 20	3,955.5 cu. yds	4,450.5 cu. yds	3,496 cu. yds.	2,309 cu. yds.
Portland Cement,	Frank E. Powers,	2 05	1 98	1 95	1 39	8,551 bbls.	13,885 bbls.	8,006 bbls.	8,097 bbls.
Rosendale Cement,	Smith-Green Co.,	0 71	0 84	0 98	0 90	3,694 bbls.	2,770 bbls.	3,363 bbls.	1,717 bbls.
Vitrified Pipe,	Portland Stone Ware Co ,	....	.....	....	....	42,305 ft.	94,077 ft.	89,185 ft.	32,997 ft.
Cement Pipe,	James Draper,	.....	......	.....	.....	35,100.5 ft.	39,059 ft.	29,275 ft.	18,783 ft.
Brick,	Spiers-Fish Co.,	7 40	8 60	8 85	7 85	2,835,700	2,334,093	2,142,000	1,971,650
Lime,	Frank E. Powers,	4 80	4 92	5 19	6 30	3,507 tons	3,884.6 tons	2,630.5 tons	2,273 tons

TABLE III.

RECORD OF TESTS ON ROSENDALE CEMENT- NEAT. JUNE 1, 1898, TO DECEMBER 1, 1898.

BRAND.	Number of Samples Tested.	*FINENESS. Per Cent. Passing Through Sieve.			TENSILE STRENGTH.											Specific Gravity.	CHEMICAL ANALYSIS.								
		No. 50.	No. 100.	No. 200.	24h.	7d.	28d.	3m.	6m.	9m.	12m.	18m.	24m.	30m.	36m.		CaO	SiO_2	Fe_2O_3	Al_2O_3	MgO	SO_3	Loss.	Insol.
Hoffman,	6	....	....	....	106	161	255	348	384	387	406	405	425	432	324	3.197	34.23	24.30	5.22	6.04	21.22	1.88	4.35	1.33
Norton,	3	....	....	....	94	127	260	366	366	379	368	363	340	387	357	3.165	33.95	24.58	2.24	5.74	21.34	1.72	5.18	0.91
New York,	1	....	....	....	54	111	225	330	330	353	344	369	372	....	358	3.070	34.19	26.11	5.74	8.61	16.36	1.83	7.19	0.47
DECEMBER 1, 1898, TO DECEMBER 1, 1899.																									
Hoffman,	8	97.8	90.7	....	107	154	226	343	397	406	430	429	453	448	....	3.208	34.72	24.84	4.85	7.02	20.25	1.95	4.80	0.72
Norton.	13	95.8	87.1	60.5	74	118	174	238	262	282	276	378	348	....	....	3.174	34.78	24.23	4.48	6.27	21.97	2.24	5.54	0.69
New York,	3	....	....	....	73	96	184	365	451	467	482	506	490	440	....	3.127	33.06	26.86	3.90	10.34	16.45	1.86	5.90	0.77
DECEMBER 1, 1899, TO DECEMBER 1, 1900.																									
Hoffman,	17	97.3	88.4	69.7	89	120	219	398	367	416	398	330	....	....	....	....	....	....	....	....	....	....	....	....
Norton,	7	....	....	....	83	86	....	....	....	365	411	381	....	....	....	....	....	....	....	....	....	....	....	....
Improved Rosendale,	1	99.8	98.0	89.1	122	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Obelisk,	1	97.6	91.8	82.8	94	132	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
DECEMBER 1, 1900, TO DECEMBER 1, 1901.																									
Clover Leaf,	1	99.7	94.4	64.3	135	354	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hoffman,	1	....	....	....	94	104	....	357	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
I X L,	2	99.6	96.4	75.2	170	305	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Norton,	10	94.3	84.5	54.4	107	215	331	405	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Union,	2	99.1	94.1	83.2	173	228	260	335	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

*Fineness tests made in 1898 are omitted from the table because they are not comparable with the results from methods in use since.

TABLE IV.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT. JUNE 1, 1898, TO DECEMBER 1, 1898.

BRAND.	Number of Samples Tested.	*FINENESS. Per Cent. Passing Through Sieve.			TENSILE STRENGTH.											Specific Gravity.	CHEMICAL ANALYSIS.							
		No. 50.	No. 100.	No. 200.	24h.	7d.	28d.	3m.	6m.	9m.	12m.	18m.	24m.	30m.	36m.		CaO	SiO₂	Fe₂O₃	Al₂O₃	MgO	SO₃	Loss.	Insol.
Atlas,	49	......	......	......	412	640	715	803	826	836	844	850	835	830	801	3.171	60.46	22.18	2.74	7.28	3.34	1.53	2.05	0.39
Alpha,	3	......	......	......	220	553	695	718	760	697	768	708	732	697	843	3.217	63.27	21.56	3.12	7.21	2.85	1.17	0.42	0.30
Alsen,	3	......	......	......	226	366	464	614	568	667	618	701	678	688	646	3.183	63.31	20.99	3.23	6.94	1.73	2.09	1.15	0.33
Dyckerhoff,	2	......	......	......	187	349	403	452	673	700	727	700	764	789	735	3.186	62.81	20.65	3.52	7.46	2.31	1.40	1.05	0.17
Egypt,	2	......	......	......	......	284	283	350	515	519	574	615	571	......	......	3.170	58.01	20.50	3.21	7.53	2.90	1.81	6.08	0.24
Germania,	1	......	......	......	359	439	555	703	672	669	707	692	676	660	......	3.176	64.55	22.26	2.64	6.40	1.16	1.80	1.10	0.28
Hecla,	1	......	......	......	31	209	276	437	420	511	515	528	506	492	432	2.933	38.73	12.42	1.56	2.22	12.45	0.83	28.42	3.16
Iron Clad,	1	......	......	......	......	333	425	491	654	598	647	672	626	642	760	3.193	60.86	21.46	6.47	4.75	1.77	1.97	1.48	0.49
Lehigh,	1	......	......	......	343	700	858	871	845	841	811	746	878	775	765	3.200	62.54	21.58	2.52	5.88	2.89	1.61	0.71	0.22
Saylor's,	5	......	......	......	371	621	658	723	754	834	878	892	820	856	881	3.210	61.50	22.98	2.06	5.13	5.22	1.95	0.72	0.49
Victor,	2	......	......	......	258	480	677	557	709	609	655	592	636	625	582	3.022	57.92	13.77	2.67	5.26	1.94	1.54	17.96	0.38

* Fineness tests made in 1898 are omitted from the table because they are not comparable with the results from methods in use since.

TABLE V.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT. DECEMBER 1, 1898, TO DECEMBER 1, 1899.

BRAND.	Number of Samples Tested.	FINENESS. Per Cent. Passing Through Sieve.			TENSILE STRENGTH.											Specific Gravity.	CHEMICAL ANALYSIS.							
		No. 50.	No. 100.	No. 200.	24h.	7d.	28d.	3m.	6m.	9m.	12m.	18m.	24m.	30m.	36m.		CaO	SiO$_2$	Fe$_2$O$_3$	Al$_2$O$_3$	MgO	SO$_3$	Loss.	Insol.
Atlas.	30	99.9	94.0	73.1	339	667	789	780	837	806	811	850	843	805	575	3.178	59.95	21.59	2.60	6.87	3.77	1.39	1.86	0.44
Alpha. .	3	......	......	......	.....	370	526	580	590	619	572	.....	.....	.....	......	3.254	63.08	21.01	2.82	7.52	3.09	1.01	0.36	0.28
Alsen,	3	......	......	......	168	595	500	587	694	630	648	656	731	593	......	3.183	61.77	20.86	3.23	6.92	1.43	2.25	1.22	0.47
Dyckerhoff.	1	......	......	.....	175	467	579	560	663	.....	.....	.....	.....	.....	......	3.188	63.12	20.21	2.99	6.89	1.75	1.29	1.16	0.32
Germania,	1	99.9	93.3	63.8	308	452	531	620	711	.....	.....	.....	.....	.....	.....	3.192	61.63	21.50	2.71	6.21	1.46	2.33	1.31	0.78
Iron Clad,	5	......	......	......	305	460	499	590	629	652	632	584	607	636	......	3.211	62.85	21.51	2.93	7.09	2.16	1.56	0.84	0.41
Lehigh,	70	99.7	92.7	71.2	178	566	644	663	684	722	693	704	685	771	......	3.246	61.26	23.18	2.60	6.05	3.10	1.40	0.76	0.47
Nazareth,	1	100.0	99.4	77.4	190	462	477	627	.....	737	.....	.....	.....	.....	.....	3.173	57.74	20.83	2.34	6.70	3.49	1.07	3.82	0.99
Saylor's,	8	......	......	......	219	613	709	749	821	890	880	907	871	829	.....	3.209	60.58	23.36	1.90	4.86	4.96	2.00	0.52	0.54
Standard,	1	98.8	90.0	71.2	142	307	423	.....	.....	.....	.....	.....	.....	.....	......	3.030	50.90	24.05	2.89	6.03	3.01	2.45	5.70	2.32
Star,	1	99.9	93.5	......	299	736	.....	745	823	753	.....	.....	.....	.....	.....	3.204	61.92	22.03	2.63	6.69	3.37	1.64	0.80	0.66
Steel,	1	100.0	98.0	......	159	374	511	.....	.....	.....	.....	.....	.....	.....	.....	2.870	51.72	28.64	0.85	11.55	3.87	0.38	3.32	0.44
Victor,	3	......	......	......	325	494	592	635	688	714	718	667	684	674	......	3.040	58.84	14.09	2.16	4.52	1.73	0.98	15.65	1.07

TABLE VI.

RECORD OF TESTS ON PORTLAND CEMENT—[illegible]BER 1, 1899, TO DECEMBER 1, 1900.

BRAND.	Number of Samples Tested.	FINENESS.			TENSILE STRENGTH.								
		Per Cent. Passing Through Sieve.											
		No. 50	No. 100	No. 200	24h.	7d.	28d.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alpha...........	1	99.3	91.7	73.7	228	698	75		494				
Dragon.........	48	99.7	94.4	75.8	250	584	622	811	900	[illegible]	[illegible]	792	[illegible]
Krause.......	2	98.7	94.0	74.3	254	705	788	783	[illegible]				[illegible]
Lehigh.........	21	99.7	98.2	78.1	188	630	695	718	[illegible]	683	[illegible]		
Nazareth	1	99.9	99.5	91.2	296	738							
Phœnix	3	99.7	98.0	85.8	307	772	731	742	831	[illegible]	[illegible]		[illegible]
Roman Rock....	1	94.0	80.9	66.6	118	184							
Star............	4	99.7	98.1	72.4	308	324	517	582	513	[illegible]	445		[illegible]
Standard	1	99.9	93.8	71.8	208	400							
Storm King....	1	96.7	87.3	74.4	178	291			...				
Uncle Sam......	1	92.5	80.0	67.5	144	313							

TABLE VII.

RECORD OF TESTS ON PORTLAND CEMENT—NEAT. DECEMBER 1, 1900, TO DECEMBER 1, 1901.

BRAND.	Number of Samples Tested.	FINENESS.			TENSILE STRENGTH.						Specific Gravity.
		Per Cent. Passing Through Sieve.			24h.	7d.	28d.	3m.	6m.	9m.	
		No. 50	No. 100	No. 200							
Atlas	7	99.8	92.2	74.5	328	623	......	......	......	......	......
Dragon	61	99.4	95.0	75.2	419	747	611	817	773	876	3.232
Germania	1	99.9	94.0	65.6	416	484	......	......	......	......	......
Helderberg	1	99.9	99.6	92.5	295	716	750	725	707	......	......
Lehigh	2	99.5	91.1	70.8	447	883	......	......	......	......	......
Nazareth	2	99.8	96.2	76.7	389	763	706	......	......	......	......
Universal	1	99.9	97.6	78.3	508	843	......	......	......	......	......
Vulcanized	1	......	......	......	225	837	......	......	......	......	......
Whitehall	1	99.8	94.9	86.3	261	766	797	664	......	......	......

TESTING LABORATORY.

The work done in this laboratory has remained about the same as last year, and has proved of material value.

The tests of cement are becoming more and more valuable and interesting as more of the long-time tests are obtained. This year the first 36 months' tests were completed.

The department met with severe loss in the death of Mr. Edward L. Smith, who had been connected with the work for several years as a chemist. Mr. Smith was largely instrumental in the establishment of the laboratory for testing supplies, and to his careful and conscientious work much credit is due for the success attained.

The records of rainfall are presented in Tables VIII and IX. The observations are made at the purification works.

It is interesting to note that there have been no heavy showers during the year. There were only six showers in which the precipitation in twenty minutes exceeded one-half inch, and none in which it was more than one inch.

INCHES OF RAINFALL AT PURIFICATION WORKS, 1900-1901.

Date.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.
1	....	....	....	....	....	....	....	....	....	0 47	....	0.08
2	....	....	....	....	0.07	....	....	0.12	....	....	....	....
3	0.05	....	....	....	1.50	....	....	....	....	....	0.55	....
4	1.35	....	0.67	0.33	0.19	....	....	....	0 02	....	....	....
5	0.17	....	....	0.12	....	....	....	0.18	....	....	....	....
6	....	....	....	....	0.80	....	....	....	....	....	0.08	....
7	....	....	....	....	0.83	....	0.36	....	1.20	....	....	....
8	....	....	....	0.05	0.06	....	0.04	....	....	....	....	....
9	....	0.10	....	0.26	0.03	0.08	....	....	....	....	....	....
10	....	0.29	....	....	0.03	0.69	....	....	....	....	....	....
11	....	0.35	....	1.68	....	0.05	....	....	....	0.37	....	....
12	....	0.34	....	....	....	....	....	....	....	0.15	....	0.33
13	....	....	....	....	....	0.26	....	....	....	0.23	0.08	....
14	....	....	....	....	....	....	....	....	....	....	1.92	....
15	....	....	....	....	0.13	....	....	....	....	0.27	....	....
16	....	0.05	....	0.02	0.03	....	....	....	....	....	....	....
17	....	0.06	....	0.06	....	....	....	....	0.20	0.53	0.05	....
18	....	....	....	....	....	0.63	....	0.37	0.18	0.03	....	....
19	....	....	....	....	....	0.68	....	....	0.10	....	....	0.09
20	....	....	....	0.33	0.23	....	....	....	0.17	....	....	....
21	....	....	....	0.74	0.56	....	....	....	....	....	....	....
22	....	....	....	....	0.36	0.04	0.66	....	....	....	....	....
23	....	....	....	....	0.10	0.05	0 17	....	....	....	....	....
24	0.17	....	....	0.17	0.79	0.63	....	0.62	1.47	....	....	1.37
25	....	....	....	....	0.63	....	....	....	....	....	....	0.07
26	....	....	....	0.93	....	0.20	....	....	....	....	....	....
27	....	....	....	0.05	....	0.81	....	....	....	....	....	....
28	0.08	....	....	....	....	0.10	....	....	....	....	....	....
29	....	....	....	....	....	0.02	....	0.49	....	0.87	....	....
30	0.16	....	....	....	0.30	0.07	....	0.02	....	0.02	....	....
31	0.07	....	....	....	....	....	....	....	....	....	....	....
Total.	1.82	1.19	0.67	4.74	6.64	4.31	1.23	1.80	3.34	2.94	2.68	1.94

Grand total, 33.30.

TABLE IX.

RAINFALL AT THE PURIFICATION WORKS DURING FISCAL YEAR OF 1901.

		Duration of Storm.		Total Precipitation in Inches.	Rate per Hour in Inches.	‡20 Minutes of Maximum Precipitation.	Period of Greatest Precipitation.		Rate per Hour in In.
		Hours.	From				Hours.	From	
December	3-4-5	43.0	11.00 P.M. of 3rd,	1.40*	.03	.27	17.5	10.20 A.M. of 4th,	.09
"	24	10.3	12.00 P.M. of 23rd.	0.17	.02	....	....	....	....
"	28	....	....	0.08*	....	....	....	....	....
"	30	5.0	9.00 P.M.	0.16	.03	....	....	....	....
"	31	5.0	12.00 P.M. of 30th,	0.07	.01	....	....	....	....
January	9	15.0	7 00 A.M.	0.10	.01	.06	....	....	....
"	10	10.0	1.00 P.M.	0.29*	.03	.06	4.0	1.00 P.M.	.06
"	11-12	21.0	2.00 P.M. of 11th,	0.89†	.04	.06	....	....	....
"	16	....	....	0.05	....	....	....	....	....
"	17	....	....	0.06*	....	....	....	....	....
February	4	20.0	4.00 A.M.	0.67*	.03	.12	....	....	....
March	4	3.3	1 00 P.M.	0.15	.05	.06	....	....	....
"	4-5	9.7	5.00 P.M.	0.30*	.03	.15	1.0	10.00 P.M.	.12
"	8-9	9.3	10.00 P.M.	0.31	.03	....	....	....	....
"	11	14.7	1.00 A.M.	1.68	.11	.48	7.0	7.00 A.M.	.20
"	16	....	....	0.02	....	....	....	....	....
"	20-21	20.0	12.00 M.	1.07	.05	.42	4.5	1.00 A.M. of 21st,	.14
"	24	7.7	2.00 P.M.	0.17	.02	.06	4.0	4.00 P.M.	.04
"	26-27	22 3	2.40 A.M. of 26th.	0.96	.04	.36	7.3	3.00 A.M.	.09
April	2-3-4	36.7	11.00 P.M. of 2nd.	1.76	.05	.24	8.3	3.00 A.M. of 3rd.	.15
"	6-7	29.0	3 00 P.M. of 6th.	1.63	.06	.21	10.0	8.00 P.M. of 6th,	.13
"	15-16	5.5	7.20 P.M.	0.16	.03	....	....	....	....
"	20-25	126.3	2.40 P.M. of 20th.	2.67	.02	.27	....	....	....
"	30-1	13.7	2.20 P.M. of 30th,	0.32	.02	.15	1.7	9.40 P.M. of 30th,	.10
May	2-3	15 7	12.40 P.M.	0.35	.02	.27	1.7	10.40 P.M.	.10
"	10	5.7	12 00 P.M. of 9th,	0.11	.02	.06	1.3	12.20 A.M.	.05
"	10-11	14.3	2.00 P.M.	0 71	.05	.24	2.0	2.20 P.M.	.13
"	13	6.3	3.20 A.M.	0.26	.04	.12	....	....	....
"	18-19	16 3	7.40 A.M. of 18th.	1.31	.08	.15	2.5	3.00 P.M.	.10
"	22-23	6.7	11.40 P.M. of 22nd.	0.09	.01	.06	....	....	....
"	24	5.8	5 00 P.M.	0.63	.11	.27	4.3	5.00 P.M.	.14
"	26-27	7.0	9.40 P.M. of 26th.	0.33	.05	.21	1.0	11.00 P.M. of 26th,	.18
"	27-28	14.7	2 20 P.M. of 27th,	0.91	.06	.15	4.3	2.40 P.M. of 27th,	.10
"	29	6 7	5.00 P.M.	0.02	....	....	....	....	....
"	30	0.7	8.00 P.M.	0.07	.10	.15	....	....	....
June	7-8	10.7	4.40 P.M.	0.40	.04	.12	1.7	10.20 P.M.	.09
"	22	5.3	5.00 A.M.	0.66	.12	.66	1.3	6.20 A.M.	.39
"	23	6.5	12.00 P.M. of 22nd,	0.07	.01	....	....	....	...
"	23	1.0	3.20 P.M.	0.10	.10	.21	....	....	....
July	2	3.0	5.00 P.M.	0.12	.04	.06	....	....	....
"	5	10 0	12.00 P.M. of 4th,	0.18	.02	.06	....	....	....
"	8	1.3	8.00 P.M.	0.07	.05	.12	....	....	....
"	12	15.0	4.00 A.M.	1.00	.07	.27	6.0	5.00 A.M.	.14
"	18	2.2	12.40 P.M.	0.37	.17	.63	0.7	12.40 A.M.	.45
"	24	8.0	12.40 P.M.	0.62	.08	.30	2.3	2.20 A.M.	.20
"	29	6.0	12.20 A.M.	0.49	.08	.30	1.3	12.20 A.M.	.20
"	30	0.7	12.00 P.M. of 29th.	0.02	.03	....	....	....	....
August	4	....	1.00 P.M.	0.02	....	....	....	....	....
"	7	13.0	1.00 A.M.	1.10	.08	.51	5.3	7.20 A.M.	.15
"	17-18	14.0	3.00 P.M.	0.48	.03	.39	1.0	12.40 A.M.	.12
"	19	14 0	5.40 P.M.	0.10	.01	....	....	....	....
"	20	2.0	10.00 P.M.	0.07	.04	....	....	....	....
"	24	12.7	1.20 P.M.	1.47	.12	.87	4.7	6.20 P.M.	.29
September	1	14.5	6.20 A.M.	0.47	.03	.27	1.7	11.00 A.M.	.17
"	11	3.5	6.20 A.M.	0.19	.05	.24	....	....	....
"	11-12	14.0	4.00 P.M.	0.22	.02	.21	....	....	....
"	12-13	14.7	4.00 P.M.	0.17	.01	.27	....	....	....
"	13	2.0	4.40 P.M.	0.17	.09	.33	....	....	....
"	15	22.7	7.20 P.M.	0.27	.01	.30	1.0	7.20 P.M.	.15
"	17-18	0.5	10.40 A.M.	0.56	.11	.90	0.7	10.40 A.M.	.74
"	29	7.7	3.00 A.M.	0.63	.08	.52	2.3	5.40 A.M.	.21
"	30	1.7	12.00 P.M. of 29th.	0.26	.20	.48	....	....	....
October	3	3.7	8.20 A.M.	0 55	.15	.45	0.7	8.20 P.M.	.41
"	6	1.5	2.20 A.M.	0.08	.05	.09	0.7	2.40 A.M.	.07
"	13-14	37.5	10.20 A.M. of 13th.	2.00	.05	.36	8.7	7.40 A.M.	.14
"	17	1.0	1.40 P.M.	0.05	.05	.06	....	....	....
November	1	2.5	3.20 P.M.	0.08	.03	.06	....	....	....
"	12	20.0	2.20 A.M.	0 33	.02	.06	....	....	....
"	19	24.0	12.00 P.M. of 18th,	0.09†	....	....	....	....	....
"	24-25	22.0	7.00 A.M.	1.44†	.07	.21	6.7	8.00 A.M.	.10

*Snow. †Snow and rain. ‡Rate per hour in inches.

MAINTENANCE.

The large increase in the size of the sewer system which has taken place during the last few years, has called for a continual increase in the amount of work required for the proper maintenance of the same. The automatic regulating gates, siphons, and special devices call for considerable attention, both for cleaning and maintaining the appliances in good working order.

At the beginning of the year there were 2,288 catch-basins, and this year 136 new ones have been constructed. The cleaning of these basins comprises a very material part of the work of maintenance, but the proper care of these basins prevents the expenditures of a very large amount of money for the cleaning of the sewers, because the refuse can be removed from the basins at a small fraction of the cost of removing it from the sewers. There have been removed from these basins 12,986 cubic yards of refuse. This has been hauled away at the rate of one and one-fifth yards per load, and at the cost of 61 cents per cubic yard, including the entire expense of hauling, as well as removal, from the catch-basins. An important factor in the cost of this work is the length of haul, which increases each year, as the old dumps located near the centre of the city are abandoned.

The work done by the public service corporations in the streets has required expensive repairs of catch-basins and manholes. This work is not classified with the natural repairs and maintenance of the system, but is classed in a separate item, as seen in the accompanying table.

The recommendations made in the last report are again presented for consideration at this time. The condition of the sewer in Shrewsbury street grows worse each year, and the paving of the Millbrook channel is just as urgent as ever. Aside from a few minor repairs, which will be made during the coming winter, the system is in very good condition, and there are no expensive repairs which are liable to be required for several years.

A classification of the expenditures in the sewer maintenance account is as follows:

Total cost of repairing old basins, sewers and manholes,	$2,063 51
Total cost of cleaning sewers,	7,745 51
Total cost of cleaning catch-basins,	7,896 60
Total cost of work chargeable to other parties cleaning catch-basins,	68 49
Total cost of work chargeable to other parties repairing catch-basins,	4,864 67
Thomas Mattson, damages to person,	250 00
Total,	$22,888 78

It will be noticed that the sum of $17,705.62 is the net cost of the maintenance of the sewer system during the past year. Basing the calculation upon the number of miles of sewers at the beginning of the year, namely, 151.086 miles, the cost per mile for total maintenance charges would be $117.19. This includes the maintenance of 2,288 catch-basins and 5,807 manholes. The cost of cleaning the sewers per mile has been ~~$5.13.~~ 57,29

CONSTRUCTION.

This year 3.909 miles of sewers have been constructed in the department of general construction. Upon these sewers 134 manholes and 22 catch-basins have been built. The total system now includes 158.463 miles of sewers, 6,064 manholes and 2,424 catch-basins.

There have been 586 permits issued during the year for connection with public sewers; of these 143 were for surface water, 388 for sewage, 7 for repairs and 48 were not used, making 551 new drains constructed. In 57 cases surface water and sanitary drains were kept separate as far as the curb and then joined, running to the main sewer in a single pipe. The total length of the drains constructed amounted to 4.58 miles.

The following is a brief schedule of property for which the department is responsible:

Personal property,	$53,205 52
Stock on hand,	4,822 98
Buildings and machinery, East Worcester street,	11,092 75
Land, 1,700 feet on Hammond street,	425 00
Land, 18,060 feet on East Worcester street,	7,224 00
Land, 33,221 feet on East Worcester street,	13,300 00
Total,	$90,070 25

Purification Works:

Land,	$74,485 99	
Buildings and machinery,	68,191 15	
Filtration area,	56,104 56	
Precipitation plant,	265,628 75	
Total,		$464,410 45

Sewer system, including cost of sewers, catch-basins, etc.:

Separating system (Statute of 1897 and 1900),	$957,510 29
General construction,	3,577,311 98
Total,	4,534,822 27
Grand total,	$5,089,302 97

There have been no very expensive or difficult constructions called for in this branch of the work, and the total length of sewers built has been rather under the average for the last few years. Considerable advance has been made towards providing sewers in Greendale, and this district is now provided with a trunk sewer, and a very good beginning has been made toward putting in the laterals. The sewer in Barber avenue was much needed to accommodate the Odd Fellows' Home, and, undoubtedly, will assist in developing the property in that neighborhood, as the soil is very heavy and poor for cesspools. The sewer in Hillside street was quite expensive on account of the large amount of ledge encountered, but was much needed, and there are several new buildings contemplated which will be accommodated by it.

In the near future work should be begun and continued systematically until the Lake View district is properly provided for. There are quite a number of houses to be accommodated, but in order to reach them considerable preliminary work must be done, which will make the system rather expensive to start with.

The trunk sewer from Webster square, running up through Beaver brook valley, which has been agitated for several years, is very much needed, and as it will take a year before work can be begun on laterals, that work ought to be started very soon.

In 1900 an order was passed calling for the walling, widening and straightening of the Middle river channel. Before work could be begun, however, several changes in the plan were suggested, and for that reason nothing was done upon construction. Finally, an order was passed providing for a more elaborate treatment of the case than was previously contemplated, but no money was provided with which the work could be done this year. In fact, the order for construction was passed so late in the season that work upon it this year would not have been advisable. This is work which should be done during dry weather, because the freshets, which are liable to occur in the spring and fall, together with ordinary high water, would be a source of considerable expense.

An act was passed by the Legislature which gives the city the necessary right to improve the channel of Beaver brook, by widening, deepening and straightening, as may be found necessary. This is a matter which could well be treated during several years, a portion being done each year. In that way reasonable progress would be made toward furnishing relief from the floods which are so annoying to tenants and property owners in that district.

A list of the streets in which sewers have been built, together with the approximate location of the work, the sizes of the pipes, the lengths, the number of manholes, and the cost of the same, is presented in the following tables:

TABLE X.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1901.

SANITARY SEWERS — CONSTRUCTION.

STREET.	REMARKS.	Size.	Length.	M. H.	Cost.
Alpine,	Seymour st. to Hillside st.,	12″	483.8′	3	$4,085.43
Barber Ave.,	West Boylston st., southerly,	8	1,497.3	9	3,574.40
Barber Ave., E.,	Barber ave., easterly,	8	234.6	1	908.00
Barber Ave..	Barber ave., east to Adams ave.,	8	288.6	1	*
Boyden,	Southbridge st. to Clay st.,	8	600.9	2	2,219.43
Bremer,	Whittier st., westerly,	10	446.2	3	788.84
Channing,	Harrington ave., northerly,	15 12	315.9 908.7	9	3,108.63
City View,	College st., easterly,	8	184.3		4,388.00
Clapp,	Washburn st., easterly,	8	421.3	4	1,387.72
Eastern Ave.,	Catharine st., northerly, extension,	10	197.0	2	773.08
Forbes,	On old sewer at Westminster st.			1	
Hillside,	Alpine st. to Vernon st.,	10	628.2	6	†
Holland road,	Main st., northerly,	8	129.1	1	2,305.82
Ingleside Ave.,	Hamilton st., northerly,	8	513.3	3	690.08
Lake,	Baker st. to Mill st.,	8	1,088.1	5	1,736.98
Lovell,	Englewood ave. to Maywood st.,	8	77.6	1	
Lund,	Esther st. to Louise st.,	8	405.9	1	1,146.53
Maywood,	Lovell st., southerly,	8	177.0	1	749.39
Millbury,	Greenwood st., southerly, flushing tank at end,	8	1,505.4	7	3,329.32
Mott,	Penn ave. to Coral st.,	8	245.6	2	674.01
Orne,	Westminster st. to Windsor st.,	8	321.6	2	1,013.64
Orne,	Windsor st. to Channing st.,	8	332.5	3	437.45
Park Ave.,	Salisbury st. to Drury lane,	8	730.0	3	2,362.54
Princeton,	Lewis st., westerly,	8	102.2	2	248.41
Riedl place,	Townsend st., southerly,	8	204.4	2	523.00
Sewer location,	Weasel brook to W. Boylston st.,	15	239.1		1,788.70
Tatman,	Ext'n westerly to Stockholm st.,	8	557.6	4	875.43
Tyler Ave.,	Barber ave., easterly,	8	140.0	1	‡
Union Ave.,	Cutler st. to Mendon st.,	10	328.1	3	678.45
Waconah road,	Park ave. to Whitman road,	8	471.3	4	706.58
West Boylston,	Sewer location, southerly,			1	
West Boylston,	At Barber ave.,			1	
West Boylston,	Sewer location to Francis st.,	15 12	872.3 537.7	9	§
Westminster,	Forbes st., southerly,	8	152.2	2	373.56
Windsor,	Washington ave., northerly,	10	280.4	2	481.57
Wayne terrace,	Wayne st., westerly,	8	203.2	2	288.12

* Included in cost of Barber avenue, east.
† " " Alpine street.
‡ " " Barber avenue, West Boylston street, southerly.
§ Not completed December 1.

TABLE XI.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1901.

SURFACE SEWERS—CONSTRUCTION.

STREET.	REMARKS.	Size.	Length.	M. H.
Boyden,	Stillwater pond to Clay st.,	15″	338.5′	2
		12	317.5	
Brooks,	Kendrick br'k to W. Boylston st.,	42	108.7	1
Cambridge,	Webster sq., southeast extension,	12	422.2	3
Caro,	Curve from Boyden st.,	12	28.8	1
Clapp,	Washburn st., easterly,	12	397.4	3
City View,	College st., easterly,	10	184.3	1
Greenwood,	Outfall ave. to Tatman st.,	18	218.0	1
Holland road,	Main st., northerly,	12	126.4	1
Lund,	Esther st. to Louise st.,	10	409.3	2
Park Ave.,	Salisbury st. to Drury lane,	15 oval	306.9	3
		15	398.1	
Riedl place,	Townsend st., southerly,	10	195.2	2
Salisbury,	On old sewer at Park ave.,			1
West Boylston,	Sewer location, northerly,	36	491.5	5
		12	240.9	
West Boylston,	Brooks st. to Francis st.,	42	63.6	4
		30	326.9	
		24	198.6	
West Boylston,	At Barber's Crossing,	24	98.0	1

NOTE.—The costs of the above sewers are included in the costs in Table X for sewers in streets of the same names.

TABLE XII.

RECORD OF SEWERS CONSTRUCTED DURING THE FISCAL YEAR OF 1901.

SANITARY SEWERS — STATUTES OF 1900.

STREET.	REMARKS.	Size.	Length.	M. H.
Blackstone,	Bridge st., northerly,	10"	[illegible]	5
	On old sewer,	8	[illegible]	1
Briden,	Garden st. to sewer location,	26 x 34	[illegible]	1
Bridge,	Summer st. to Blackstone st.,	10	244.7	1
Burt,	Grafton st. to Temple st.,	10	[illegible]	3
***Cambridge,**	24" invert in old 60" x 84" sewer,		142.0	
Cemetery,	Prescott st. to Grove st.,	26 x 34	1,008.8	6
Central,	Union st., easterly,	8	160.3	1
Central,	Summer st., westerly,	8	[illegible]	3
Charles,	Blackstone st., easterly,	8	97.5	1
Foster,	Summer st. to viaduct,	8	[illegible]	4
Franklin,	Harding st. to Grafton st.,	8	[illegible]	3
Front,	Warren st. to Millbrook,	10	[illegible]	2
	On old 26" x 39" sewer,			1
Garden,	Garden st. court to Briden st.,	30 x 40 26 x 34	112.5 462.7	3
Garden,	Briden st. to Prescott st.,	30	221.4	4
Grafton,	Franklin st. to Washington sq.,	40 x 54	[illegible]	1
Grove,	On old 40" x 60" sewer,			1
Harding,	Temple st. to Franklin st.,	8	294.0	3
Harding,	Green st. to Harrison st ,	8	601.3	5
Howard,	Blackstone st., easterly,	8	198.2	1
Lincoln,	S. line of Lincoln sq. to Keefe pl.,	32 x 42 30 x 40	140.8 1,221.8	7
Millbury,	Siphon chamber, southerly,	8	300.0	5
Prescott,	Sewer location to Cemetery st.,	26 x 34	463.7	3
	On old sewer,			1
School,	Union st. to Summer st.,	8	403.2	2
Sewer location,	Lincoln to Garden st.,	30 x 40	624.5	4
Sewer location,	Briden to Prescott st.,	26 x 34	224.5	1
Summer,	Wash'n sq. to s. line of L'nc'n sq.,	40 x 54 32 x 42	343.3 3,017.1	18
Temple,	Burt st., easterly,	8	145.8	2
Thomas,	Summer st. to Union st.,	15	618.3	4
	On old 26" x 39" sewer,			1
Union,	Thomas st. to Central st.,	8 12	351.8 301.4	3
Union,	Thomas st. to Lincoln sq.,	10 8	274.2 103.2	10
Washington Sq.,	East intercepter, westerly,	12 10	30.0 382.0	3
Winter,	Water st. to Harding st.,	8	322.8	3

* Not to be added to total length of system.

TABLE XII.

DS CONSTRUCTED DURING THE FISCAL YEAR OF 1901.

OF SEWERS—STATUTES OF 1900.

Location.	Size.	Length.	M. H.
[illegible]	[illegible]	[illegible]	[illegible]

Green street, described in detail in the annual report for 1899. The drift was six feet in diameter, being lined with wooden rings and masonry to the required size and shape. The masonry was placed in this tunnel as the work progressed, and no material difficulty was experienced because of the small size, viz., 40x54 inches and 32x42 inches.

The total cost of this tunnel was $37,851.31, including cost of Shrewsbury street regulator, amounting to $37.40 per running foot of sewer built.

The work in Summer street was carried on in three different sections at the same time. The excavations were very heavy, ranging from 15 to 30 feet deep, and having an average depth of about 23 feet. In Lincoln street ledge was encountered a short distance above Kendall street, and materially delayed the completion of the intercepter. A short section, including the curve from Lincoln street into Keefe place, was built in tunnel, as the cut was very heavy, and the ledge cropped out on the surface of the street.

It was while engaged upon this work that the lamentable accident occurred which resulted in the death of David Gleason. Mr. Gleason was employed to run the small air-compressor which furnished air for the operation of the drills. For some unknown reason he left the compressor and stepped onto the street railroad track immediately in front of an approaching car, by which he was struck.

As soon as the intercepter was completed so as to provide an outlet for sewage, the section lying between Summer street and Millbrook was resewered. As the old sewers in this district graded toward Millbrook, it became necessary to construct new ones which could discharge into the intercepter. This also required the transferring of all house connections from the old lines to the new ones.

This work was made especially difficult in Union street because Millbrook occupies the entire roadway, and the new constructions were necessarily put in the sidewalk. It was at times difficult to get sufficient room for the pipe between the wall of Millbrook and the building foundations.

PURIFICATION.

The sewage has been treated in various ways, but always with a view to obtaining best results in the river. To accomplish this the purpose has been to filter as large an amount as possible, and procure a filtrate in which the organic matter was reduced to such an extent that it would not become offensive. Accordingly, little attention has been paid to nitrification, which, with a sewage so strongly acid, is difficult to obtain. The limited filtering area, 14 1-5 acres, has, of course, prevented treating a very considerable portion of the flow in this way.

Throughout the year the most polluted sewage has been selected for filtration, which has had a material effect upon the results shown by chemical analysis, as well as upon the amount of sewage the filters would take care of.

TABLE XIV.

COST OF MAINTAINING SEWAGE DISPOSAL WORKS.

Date.	Amount Treated (Gallons.)	Cost.	Cost per Million Gals.	Population.	Cost per Capita.
1890	391,000,000	$47,919 60	$122 55	84,655	$0 56
1891	1,398,000,000	27,761 95	19 86	87,547	0 32
1892	842,000,000	27,575 24	32 74	90,439	0 30
1893	1,795,000,000	24,103 23	13 43	93,138	0 26
1894	4,562,000,000	25,145 21	5 51	95,982	0 26
1895	5,730,000,000	46,847 46	8 17	98,767	0 47
1896	5,840,000,000	43,264 23	7 41	102,698	0 42
1897	6,205,000,000	69,165 64	11 14	106,629	0 65
1898	6,460,000,000	64,440 83	9 97	110,560	0 58
1899	6,241,000,000	84,694 98	13 57	114,492	0 74
1900	4,781,000,000	50,073 34	10 47	118,421	0 41
1901	3,565,000,000	43,773 99	12 27	122,803	0 35

NOTE.—The costs for 1895-1899 include considerable money spent on construction, but which cannot be separated from maintenance charges because both items were kept in the same account. This is also true for the figures given for 1890.

The total flow of sewage received at the works was 3,564.7 million gallons, of which 3,133.8 million gallons have been treated chemically, and 320.40 million gallons have been treated by subsidence. The only analyses which show the results of subsidence without chemicals were made during October and November, and show a removal of albuminoid ammonia amounting to 39.84 per cent. and 53.43 per cent., respectively. In November the sewage was very strong, the total albuminoid ammonia amounting to 1.342 parts per 100,000 parts, which had much to do with the high percentage removed.

The separating system was finally put into use September 6, and on October 30 the last trunk sewer connection was made to the east intercepter.

This change in the sewer system will be of very great value in the treatment of the sewage and the improvement of the Blackstone river. By the new system the sewage is intercepted before it reaches Millbrook, and flows direct to the purification works. The waters from North and Salisbury's ponds discharge through Millbrook into the Blackstone river, relieving the purification works to the extent of that flow, which in dry weather amounts to about 5,000,000 gallons per day, and in time of storm and freshet frequently rises to several scores of millions. In the future there will be a discharge from the sewers into Millbrook during storm, but this will cease long before the flow in Millbrook will reach a volume which could be taken to the works. During the storm the intercepters will conduct to the purification works so much of the combined sewage and street water as the size of the outfall sewer will permit. This sewage will be much less diluted than when taken by the outfall sewer from Millbrook, and a much larger proportion of the sewage will be treated than was possible under the old system.

Besides the gain in time of storm there will be further improvements from the fact that the flow of Millbrook will be comparatively pure water at other times and will flow into the river ready to do its part in purifying the stream by dilution and furnishing its supply of dissolved oxygen.

The cost of maintaining the purification works for the year has been $44,352.82, amounting to 36 cents per capita. The amount of sewage treated has been reduced by the use of the new system of intercepting sewers, so that the cost per million gallons has increased somewhat over that of previous years. It should be stated that necessary repairs and improvements to plant have been prevented by lack of funds, which fact will make a larger appropriation for 1902 very necessary.

The results of the work done are given in Table XV, which is made up by calculation from the various analyses and measurements. As would be expected, the amount of purification has been increased by the addition of filtration to the treatment. However, as only about one-third of the sewage has been filtered, and that at a very rapid rate, much better results may be confidently expected to result from the smaller amount of flow in the future, resulting from the completion of the intercepting system, as well as from the increase of filtering area, which should be provided in the near future.

The average daily flow of sewage treated has amounted to 9.76 million gallons, of which about one-third has been filtered.

In addition to the large proportion of organic matter removed, it should be remembered that the river water has been separated from the sewage during a portion of the time, which materially improves the net effect upon the river.

During July and August. the two months when the river is most offensive, it will be noticed that the purification amounted to 73.43 per cent, removal of albuminoid ammonia. During this time, as through the most of the year, the floating or suspended organic matter was practically entirely removed.

From Table XVI it will be seen that material improvement in the quality of effluent has resulted from the more complete treatment afforded by the methods adopted during the year. Table XVII gives the results of analyses by seasons, and is of especial interest in connection with a study of the effect of the treatment of the sewage upon the condition of the river. It is of interest to note the gain of 10 per cent. in the purification during the summer season over that of preceding years.

TABLE XV.

COMBINED RESULTS OF SEWAGE TREATMENT.

Monthly Averages of Analyses of Sewage and Effluent from Chemical Precipitation, from Filtration, and from Chemical Precipitation and Filtration Combined.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals.
		ALBUMINOID.						
	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.		
Sewage, December, 1900........	1.060	.437	.172	.265	5 46	4.01	5.31	7.69
Effluent, " "	1.209	.171	.123	.048	2.62	2.30	5.31	
Per cent. removed.....	-14.06	60.87	28.49	81.91	52.01	42.65	0.00	
Sewage, January, 1901..........	2.975	.946	.494	.452	14.51	10.43	9.80	4.56
Effluent, " "	2.406	.289	.266	023	4.89	4.89	9.52	
Per cent. removed.... .	19.16	69.45	46.15	97.14	64.79	53.13	2.86	
Sewage, February, 1901	3.010	.927	.516	.411	12.85	10.47	9.29	6.08
Effluent, " "	2.673	.418	.375	.043	7.94	7.94	9.39	
Per cent. removed......	11.19	54.91	27.33	89.54	38.21	24.16	-1.08	
Sewage, March, 1901............	2.196	.781	.396	.395	11.73	7.91	6.58	7.90
Effluent, " "	1.692	.442	.442	.000	6 54	6.54	7.06	
Per cent. removed.....	22.95	43.40	-11.61	100.00	44.25	17.32	-7.14	
Sewage, April, 1901.............	1.128	.418	.129	.289	7.61	4.90	5.24	8.23
Effluent. " "	1.204	.209	.209	.000	3.60	3.60	5.22	
Per cent. removed......	-6.74	50.00	-62.01	100.00	52.69	26.51	0.38	
Sewage, May, 1901..............	1.228	.383	.150	.233	5.59	3.65	4.57	12.02
Effluent, " "	1.201	.182	.182	.000	2.42	2.42	4.56	
Per cent. removed......	2.20	52.48	-21.33	100 00	56.71	33.70	0.22	
Sewage, June, 1901..............	1.632	.406	.159	.247	5.26	3.81	5.51	9.81
Effluent. " "	1.024	.120	.120	.000	2.00	2.00	5.49	
Per cent. removed... ..	37.26	70.46	24.53	100.00	61.97	47.51	0.36	
Sewage, July, 1901..............	1 367	.629	.174	.455	7.57	5.37	8.25	13.99
Effluent, " "	1.024	.167	.167	.000	2.58	2.58	8 39	
Per cent. removed ...	25.09	73.43	40 24	100.00	65.92	51.95	-1.70	
Sewage, August, 1901...........	1.308	.616	.204	.412	7.29	4.60	8.64	15.76
Effluent, " "	.856	.164	.164	.000	1.95	1.95	8.27	
Per cent. removed......	34.56	73.36	19.61	100.00	73.24	57.59	4.28	
Sewage, September, 1901.......	2.135	.727	.332	.395	9.04	5.49	11.84	10.11
Effluent, " "	1.541	.213	.213	.000	3.20	3.20	12.07	
Per cent. removed......	27.83	70.71	35.84	100.00	64.60	41.71	-1.94	
Sewage, October, 1901..........	2.483	.756	.320	.436	11.53	5.98	8.52	8.38
Effluent, " "	2.149	.257	.257	.000	3.36	2.97	8.53	
Per cent. removed......	13 45	66.01	19.69	100.00	70.86	50.34	-0.12	
Sewage, November, 1901.......	2.630	.904	.338	.566	15.03	9.25	8.94	8.66
Effluent. " "	2.250	.399	.399	.000	4.92	4.63	8.49	
Per cent. removed......	14.45	55.82	-18.05	100.00	67.28	49.96	5.03	
Average sewage, 1901...........	1.786	.632	.255	.377	8 83	5.81	7.21	9.43
Average effluent, 1901	1.454	.234	.227	.007	3.45	3.38	7.03	
Per cent. removed......	18 59	62.98	10.98	98 19	60.94	41.81	5.82	

NOTE. – This table is made up of monthly averages of analyses of sewage and effluent from chemical precipitation. from filtration and from precipitation followed by filtration combined, by calculation according to the flow treated by each of the three methods.

NOTE. The sewage figures for October and November include the unsettled sewage for the filter beds, and not the settled sewage as given in the table for Results of Filtration of Untreated Sewage.

TABLE XVI.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE.

DESCRIPTION.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
Total amount (by evaporation),	50.88	49.35	.....	......	.....	....	.....	.....	....
Amount in suspension (by evaporation),	90.67	94.45	......	......	.....	.....	......	.....	.....
Total amount (by albuminoid ammonia),	48.49	50.79	51.63	53.92	53.02	51.82	53.73	59.39	62.98
Amount in suspension (by albuminoid ammonia),	76.67	89.54	91.11	92.02	93.46	92.62	95.53	96.85	98.19
Total amount (by oxygen consumed),	33.65	43.84	54.35	51.62	52.00	48.89	51.73	55.94	60.94
Amount in suspension (by oxygen consumed),	80 85	81 08	78 01	......	.....	.....	......	....	...

NOTE.- Large quantities of sulphate of iron are present in the sewage, which make the determinations for oxygen consumed somewhat unreliable.

NOTE. The figures for 1900 and 1901 comprise the results of both the chemical treatment and treatment by filtration

TABLE XVII.

PER CENT. ORGANIC MATTER REMOVED FROM SEWAGE BY SEASONS.

DESCRIPTION.	DECEMBER TO JULY.								JULY TO DECEMBER.								
	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
Total amount (by evaporation).	42.76	—	—	—	—	—	—	—	50.88	55.02	—	—	—	—	—	—	—
Amount in suspension (by evaporation),	93.08	—	—	—	—	—	—	—	90.67	95.76	—	—	—	—	—	—	—
Total amount (by albuminoid ammonia),	46.63	49.69	52.00	48.91	48.67	49.81	62.66	56.45	48.49	53.78	52.93	56.10	57.14	54.86	57.06	56.74	68.34
Amount in suspension (by albuminoid ammonia),	83.26	91.73	91.45	92.19	93.55	94.16	97.83	95.68	76.67	94.86	90.75	93.35	94.80	91.58	96.56	95.50	100.
Total amount (by oxygen consumed),	37.11	46.92	50.78	48.84	46.90	49.85	54.50	52.07	33.65	50.23	61.08	53.15	55.46	50.84	53.31	60.15	68.47
Amount in suspension (by oxygen consumed),	89.27	82.95	—	—	—	—	—	—	80.85	92.42	72.91	—	—	—	—	—	—

The work accomplished by the purification plant has been far more satisfactory than during any previous year, and it would seem that if necessary enlargement of plant could be made, the problem of sewage disposal would be solved satisfactorily.

CHEMICAL PRECIPITATION.

The sewage not filtered has been treated with chemicals before being discharged into the river. The method of treatment has not differed materially from that followed in previous years. The increase in the amount of lime used per million gallons of sewage treated is explained partly by the very large amount of sulphuric acid contained in the sewage and partly by the greater concentration of the sewage.

Whenever circumstances permitted, that part of the chemical effluent which was most polluted and difficultly treated was filtered.

Table XVIII is a record of the results of the chemical treatment of that portion of the sewage which was not filtered, while Table XIX gives analyses of sewage and corresponding effluent which was passed through the filters. The chemical treatment has required the use of 1,498 pounds of lime per million gallons of sewage treated.

The net cost of the chemical treatment has been $20,079.26, which makes the cost per million gallons treated $6.41. To this should be added the cost per million gallons sewage treated for disposing of the sludge, $5.89, making a total of $12.30. The above cost of pressing the sludge includes the expense of pressing it, from the settled sewage, as well as that chemically treated, but is calculated on the latter only.

SLUDGE DISPOSAL.

All sludge produced during the year has been pressed, and the cake hauled by the narrow-gauge trolley road to the same dump used last year.

The total volume of sludge pumped from the settling basins to the storage tanks was 26,957,000 gallons. It was allowed to remain here as long as possible, and the clear supernatent liquor drawn off before pumping to the presses. This amounted to 2,037,000 gallons, or 7½ per cent. of the total.

TABLE XVIII.

RESULTS OF CHEMICAL PRECIPITATION OF SEWAGE FOR RIVER.

Monthly Averages of Weekly Analyses of Sterilized Daily Samples.

(Parts per 100,000.)

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals.	†Pounds Lime per Mil. Gals.
	Free.	ALBUMINOID.							
		Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.			
Sewage, December, 1900 ...	.975	.484	.163	.321	5.48	3.65	5.00	*5.81	824
Effluent, " " ..	1.000	.228	.157	.071	3.65	3.18	5.10		
Per cent. removed..	-2.56	52.89	3.68	78.20	33.39	12.87	-2.00		
Sewage, January, 1901	3.070	1.265	.578	.687	19.00	13.66	12.40	2.48	2,628
Effluent, " "	2.390	.442	.390	.043	7.97	7.97	11.88		
Per cent. removed..	22.15	65.06	30.97	93.74	58.03	41.66	4.19		
Sewage, February, 1901	3.325	1.231	.625	.606	17.12	14.01	11.40	3.43	2,442
Effluent, " "	2.638	.625	.550	.075	12.97	12.97	11.60		
Per cent. removed..	20.66	49.23	12.00	87.62	24.24	7.42	-1.75		
Sewage, March, 1901	2.150	.791	.397	.394	11.86	7.92	6.58	7.46	1,128
Effluent, " "	1.638	.457	.457	.000	6.77	6.77	7.08		
Per cent. removed..	23.82	42.22	-15.11	100.00	42.90	14.52	-7.60		
Sewage, April, 1901	1.090	.360	.115	.245	6.65	4.28	4.88	6.72	995
Effluent, " "	.940	.222	.222	.000	4.05	4.05	4.96		
Per cent. removed..	13.76	38.33	-93.05	100.00	39.10	5.37	-1.64		
Sewage, May, 1901	1.256	.345	.140	.205	4.97	3.01	4.33	9.51	942
Effluent, " "	1.044	.206	.206	.000	2.84	2.84	4.38		
Per cent. removed..	16.88	40 29	-47.14	100.00	42.85	5.65	-1.15		
Sewage, June, 1901	1.663	.405	.164	.241	4.69	2.64	5.15	5.76	1,146
Effluent, " "	1.363	.179	.179	.000	3.00	3.00	5.30		
Per cent. removed..	18.04	55.80	-9.15	100.00	36.03	-13.63	-2.91		
Sewage, July, 1901	1.310	.593	.166	.427	7.16	5.04	8.10	9.64	1,603
Effluent, " "	1.160	.206	.206	.000	3.29	3.29	7.98		
Per cent. removed..	11.45	65.25	-24,10	100.00	54.05	34.72	1.50		
Sewage, August, 1901	1.031	.575	.195	.380	7.25	4.63	7.20	9.50	1,815
Effluent, " "	.963	.221	.221	.000	2.82	2.82	7.50		
Per cent. removed..	6.60	61.56	-13.34	100.00	61.10	39.09	-4.17		
Sewage, September, 1901 ..	1.706	.722	.251	.471	7.49	4.56	10.08	5.19	1,425
Effluent, " " ..	1.869	.333	.333	.000	5.00	5.00	11.80		
Per cent. removed..	-9.56	53.88	-32.67	100.00	33.24	-9.65	-17.07		
Sewage, October, 1901	2.500	.713	.263	.450	10.25	5.80	7.82	6.34	1,728
Effluent, " "	2.400	.297	.297	.000	3.91	3.39	7.98		
Per cent. removed..	4.00	58.34	-12.93	100.00	61.86	41.56	-2.05		
Sewage, November, 1901 ...	2.675	.806	.260	.546	14.18	8.90	8.07	7.07	1,540
Effluent, " " ...	2.413	.446	.446	.000	5.67	5.32	7.98		
Per cent. removed..	9.80	44.67	-56.82	100.00	60.02	40.23	1.12		
Average Sewage, 1901	1.718	.624	.238	.386	8.76	5.71	7.02	6.58	1,498
" Effluent, "	1.501	.295	.285	.010	4.52	4.41	7.27		
Per cent. removed..	12.63	52.72	-11.34	97.40	48.41	22 77	-3.56		

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*Of this amount 1.84 million gallons per day was settled without treatment.

†These figures include lime used on sewage for filter beds from April to September inclusive.

TABLE XIX.

RESULTS OF CHEMICAL PRECIPITATION OF SEWAGE FOR FILTER BEDS.

Monthly Averages of Weekly Analyses of Sterilized Daily Samples.

(Parts per 100,000.)

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED		Chlorine.	Average Flow per Day in Mil. Gals.
	Free.	ALBUMINOID.						
		Total.	Dis-solved.	Sus-pended.	Un-filtered.	Filtered.		
Sewage, April, 1901	1.313	.697	.194	.503	12.14	7.89	6.98	1.51
Effluent, " "	1.550	.350	.252	.098	5.64	4.97	7.08	
Per cent. removed......	-18.15	49.78	-29.89	80.42	53.55	37.01	-1.43	
Sewage, May, 1901	1.125	.525	.187	.338	7.95	6.05	5.53	2.51
Effluent, " "	1.425	.229	.136	.093	3.28	2.94	5.58	
Per cent. removed......	-26.67	56.37	27.28	72.49	58.72	51.40	-0.90	
Sewage, June, 1901..............	1.588	.407	.155	.252	7.62	5.46	6.03	4.05
Effluent, " "	1.663	.246	.216	.030	2.74	2.39	5.98	
Per cent. removed......	-4.72	39.56	-39.36	88.10	64.03	56.22	0.83	
Sewage, July, 1901	1.491	.710	.191	.519	8.49	5.99	8.62	4.35
Effluent, " "	1.430	.299	.244	.055	4.54	3.84	9.22	
Per cent. removed......	4.09	57.88	-27.75	89.39	46.52	35.89	-6.96	
Sewage, August, 1901	1.731	.678	.217	.461	7.36	4.56	10.08	6.26
Effluent, " "	1.494	.311	.239	.072	3.65	3.03	9.80	
Per cent. removed......	13.70	54.14	-38.90	84.37	50.41	33.55	2.78	
Sewage, September, 1901	2.588	.732	.417	.315	10.68	6.46	13.68	4.92
Effluent, " "	2.069	.445	.421	.024	4.86	4.01	12.75	
Per cent. removed......	20.04	39.21	-0.96	92.39	54.49	37.93	6.79	
Average Sewage, 1901	1.750	.621	.239	.395	8.67	5.75	9.18	3.93
" Effluent, "	1.626	.318	.262	.056	4.10	3.39	8.95	
Per cent. removed......	7.09	47.82	-9.43	85.82	52.91	41.08	2.50	

NOTE.—During April, May and June this sewage was given only a partial treatment; during July, August and September it was given a good treatment, except the Sunday dose, which was applied untreated during August and September. This amount equals 2.30 million gallons per day for August, and 1.51 million gallons per day for September.

TABLE XX.

RESULTS OF SLUDGE PRESSING.

MONTHS.	SLUDGE.		PRESS CAKE.			POUNDS OF LIME ADDED TO SLUDGE.		COST OF OPERATION.		
	Thousand Gallons Pressed.	Per Cent. Solids.	Tons Cake.	Per Cent. Solids.	Tons Solids.	Total.	Per Thousand Gallons.	Total.	Per Million Gallons Sewage.	Per Ton Solids.
December	703	5.96	631	27.7	175	29,000	41.2	$800 84	$4 45	$4 52
January	992	6.94	1,054	27.2	287	41,500	41.8	1,152 87	14 98	4 02
February	887	7.52	1,034	26.9	278	20,000	22.5	818 03	8 53	2 94
March	1,210	7.86	1,353	29.3	396	32,500	26.9	1,357 37	5 87	3 43
April	1,140	7.37	1,156	30.3	350	25,600	22.5	1,155 59	4 74	3 30
May	2,081	6.70	1,919	30.2	581	50,000	24.0	1,091 86	2 93	1 88
June	1,860	6.65	1,641	31.4	515	49,000	26.3	1,393 71	4 73	2 71
July	5,105	4.46	3,611	26.3	950	101,500	19.9	2,327 66	5 36	2 45
August	6,044	4.26	3,866	22.6	874	78,000	12.9	2,697 40	6 46	3 09
September	3,389	4.05	2,307	24.8	572	46,500	13.7	2,084 45	8 08	3 64
October	487	7.11	456	31.9	145	12,500	25.7	582 09	2 96	4 01
November	1,022	7.68	1,124	29.1	327	12,500	12.2	1,544 39	7 28	4 72
Totals	24,920	5.25	20,152	27.0	5,450	498,600	20.0	$17,006 26	$5 48	$3 12

NOTE. The sum of $1,171.33 for incidentals and laboratory supplies is not included in the monthly costs.

It will be noticed that the cost of pressing the sludge per million gallons of sewage treated has been reduced over that of last year by $0.87, calculated only upon the flow of sewage chemically treated.

Calculating upon the entire flow through the basins, the cost has been increased by only $0.14 per million gallons. The cost of pressing per ton of solids is practically the same as during the previous year.

FILTRATION.

The filters have received an average of 220,000 gallons of sewage or chemical effluent per acre per day for every day during the year. This amount has been purified by the filters to the extent of about 75 per cent. of its organic matter, and including the purification by sedimentation and chemical precipitation, about 85 per cent. of the organic matter has been removed.

Of the various methods of treating sewage which have been tried during the year chemical precipitation, followed by filtration, gives by far the most satisfactory results, if cost is not taken into account. By this method the sewage, received before decomposition has rendered it very offensive, is treated with chemicals, and practically all of the floating matter is removed. This process is so rapid that very little offensive odor arises from the plant. The effluent is quite free from putrefaction, and may be applied to the filters in very large volumes, and will pass rapidly through the filters. As the suspended matter has been almost wholly removed, there is practically no accumulation of organic matter on the surface of the sand to decompose and generate offensive gases.

From the analyses recorded in Tables XXI and XXII it would appear that the results of treatment by this method did not vary materially from those obtained by simple subsidence, followed by filtration. It will be noticed, however, that the sewage treated with chemicals was not nearly so strong as that which was settled without chemical treatment. Had the composition of the sewage been the same in both cases the percentage purification by the chemical method would doubtless have been higher.

TABLE XXI.

RESULTS OF FILTRATION OF CHEMICAL EFFLUENT.

Monthly Averages of Weekly Analyses of Sterilized Daily Samples.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				NITROGEN AS		OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals. (Per Acre.)
	Free.	ALBUMINOID.			Nitrates.	Nitrites.	Unfiltered.	Filtered.		
		Total.	Dis-solved.	Sus-pended.						
Effluent, April, 1901	1.550	.350	.252	.098	.086	.0406	5.64	4.97	7.08	.12
Filtrate, " "	2.313	.144	.144	.000	.084	.0169	1.45	1.45	6.45	
Per cent. removed	-49.22	58.86	42.85	100.00	2.33	58.37	74.29	70.81	8.90	
Effluent, May, 1901	1.425	.229	.136	.093	.109	.1625	4.28	2.94	5.55	.19
Filtrate, " "	1.800	.096	.096	.000	.340	.0691	0.87	0.87	5.23	
Per cent. removed	-26.37	58.09	29.42	100.00	-211.90	57.48	79.60	70.42	5.77	
Effluent, June, 1901	1.663	.246	.216	.030	.120	.0490	2.74	2.39	5.98	.31
Filtrate, " "	.532	.036	.036	.000	.771	.0995	0.53	0.58	5.75	
Per cent. removed	68.01	85.37	83.33	100.00	-542.50	-103.00	80.65	61.81	3.85	
Effluent, July, 1901	1.430	.299	.244	.065	.165	.0686	4.54	3.84	9.22	.31
Filtrate, " "	.725	.080	.080	.000	.467	.0479	1.01	1.01	9.28	
Per cent. removed	11.92	73.23	67.20	100.00	-183.00	30.18	77.73	73.70	-0.65	
Effluent, August, 1901	1.494	.311	.239	.072	.067	.0870	3.64	3.03	9.80	.45
Filtrate, " "	.694	.077	.077	.000	.260	.0560	0.63	0.63	9.45	
Per cent. removed	53.55	75.23	67.78	100.00	-288.00	35.63	82.69	79.21	3.57	
Effluent, September, 1901	2.060	.445	.421	.024	.081	.0308	4.86	4.06	12.75	.35
Filtrate, " "	1.194	.087	.087	.000	.326	.0743	1.29	1.29	12.35	
Per cent. removed	42.27	80.44	79.32	100.00	-302.50	-141.20	72.80	68.23	3.14	
Average effluent, 1901	1.626	.318	.262	.056	.103	.0706	4.10	3.39	8.95	.29
Average filtrate, 1901	1.006	.079	.079	.000	.399	.0648	0.90	0.90	8.67	
Per cent. removed	38.14	74.15	69.81	100.00	287.80	8.22	78.13	73.76	3.13	

TABLE XXII.

RESULTS OF FILTRATION OF SEWAGE.

Monthly Averages of Weekly Analyses of Sterilized Daily Samples.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				NITROGEN AS		OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Mil. Gals.	Flow per Acre per Day in Mil. Gals.
	Free.	ALBUMINOID.			Nitrates.	Nitrites.	Unfiltered.	Filtered.			
		Total.	Dis-solved.	Sus-pended.							
Sewage, December, 1900	1.241	.338	.192	.146	.392	.0405	5.41	4.76	5.96	1.88	.12
Filtrate, " "	1.650	.050	.050	.000	.264	.0818	0.45	0.45	5.76		
Per cent. removed	-47.63	85.17	73.96	100.00	32.65	-102.00	91.68	90.56	3.36		
Sewage, January, 1901	2.860	.565	.394	.171	.086	.0321	9.15	6.58	6.69	2.08	.19
Filtrate, " "	2.422	.108	.108	.000	.076	.0180	1.21	1.21	6.69		
Per cent. removed	15.31	80.89	72.59	100.00	11.62	43.92	87.74	81.62	0.00		
Sewage, February, 1901	2.605	.533	.374	.159	.056	.0332	7.32	5.88	6.56	2.65	.24
Filtrate, " "	2.717	.149	.149	.000	.019	.0097	1.43	1.43	6.53		
Per cent. removed	-4.30	72.04	60.16	100.00	66.07	70.79	80.46	75.68	0.46		
Sewage, March, 1901	2.995	.608	.384	.224	.107	.0528	9.56	7.79	6.54	0.44	.04
Filtrate, " "	2.602	.180	.180	.000	.000	.0043	2.60	2.60	6.50		
Per cent. removed	13.12	70.39	53.12	100.00	100.00	91.85	72.80	66.64	0.61		
Sewage, October, 1901	2.798	.532	.401	.135	.053	.0380	8.27	6.21	10.70	2.44	.15
Filtrate, " "	1.393	.132	.132	.000	.345	.0274	1.64	1.64	10.29		
Per cent. removed	50.21	75.18	67.08	100.00	-550.94	27.89	80.17	73.59	3.83		
Sewage, November, 1901	2.790	.692	.477	.155	.050	.0565	10.02	6.25	11.66	1.59	.12
Filtrate, " "	1.725	.172	.172	.000	.316	.0430	1.56	1.56	10.76		
Per cent. removed	43.82	75.20	63.95	100.00	[illegible]	23.89	84.43	75.04	7.80		
Average sewage	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.14
Average filtrate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Per cent. removed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

NOTE.—Sewage settled in three or more tanks before filtration. [illegible]

It should also be noticed that about 300,000 gallons of chemical effluent were filtered per acre per day, while with crude sewage only about 150,000 gallons could be passed through the filters. During the month of August the amount of chemical effluent filtered reached 450,000 gallons per day per acre, and could doubtless have been increased still more without seriously diminishing the amount of purification. On the other hand, the amount of settled sewage applied to the filters appeared to have reached the limit of the capacity of the filters, although the sewage passed through the settling basins so rapidly that all the suspended matter was not removed.

An accumulation of the organic matter upon the surface of the filters always results from the application of crude sewage, no matter how well it is settled. This prevents the free access of both air and water to the pores of the filter, and gives rise to offensive odors.

The sludge produced by this method is much more expensive and difficult to press than that from chemical precipitation.

The crude sewage undergoes some putrefaction while passing through the settling basins, which, together with the exposure of the sewage on the surface of the filters, into which it does not rapidly penetrate, gives marked evidence through the surrounding territory of the method employed.

Nitrification has been very low in the filters throughout the year. This has been due partly to the high rate of filtration and partly to the acid character of the crude sewage filtered. The nitrifying organisms were more active when chemical effluent was being filtered than when the filters were receiving crude sewage. This was undoubtedly largely due to the alkaline reaction produced by the excess of lime in the effluent.

The surface of the filters was ploughed, harrowed or raked once each month, from April to October inclusive. During the latter month 492 cubic yards of material, containing a large amount of organic matter, were removed from the filters, averaging 34 cubic yards per acre.

The cost of maintaining the filters has amounted to $5,282.01, making the cost of filtering one million gallons $4.54, a reduction of $1.82 per million gallons over last year.

SLUDGE PRESS LIQUOR.

The water extracted from the sludge by the filter presses has been run on to four sand filter beds of one-half acre area each throughout the year. The results of this filtration have shown a high percentage of purification, amounting to 77.78 per cent. removal of albuminoid ammonia and about 70 per cent. of the carbonaceous matter. The amount of free ammonia in this water was very high, ranging from 5.6 to 20.5 parts per 100,000 gallons. The albuminoid ammonia has also been very high, reaching 4.9 parts per 100,000 gallons in February. About 27,000 gallons of this water has been filtered per acre per day, and with this amount and a better method of distribution, it is apparent that a higher degree of purification can be obtained.

SEPTIC TREATMENT.

This method of treatment, which might appropriately be called the municipal cesspool method, has been continued in use since May, 1900, and has given interesting results. The value attached to this method of treatment appears to be chiefly confined to the disposal of the suspended organic matter in sewage. As this is the most troublesome part of the polluting matter, any method by which it can be disposed of is worthy of careful consideration. It will be noticed that the results of the analyses given in Tables XXIV and XXV indicate that a considerable portion of the suspended organic matter has been taken out of the sewage. The flow through the tank amounted to about 300,000 gallons per day for six days in the week until September, 1901, when the flow was increased to about 500,000 gallons per day. The increase of the flow through the tank did not appear to make any material difference in the amount of organic matter removed from the water. The capacity of the tank was 350,000 gallons, about 50,000 of which might be considered as taken up with the accumulation of solid matter in the bottom.

TABLE XXIII.

RESULTS OF FILTRATION OF SLUDGE PRESS LIQUOR.

Monthly Averages of Weekly Analyses of Daily Sterilized Samples.

(Parts per 100,000.)

DATE OF COLLECTION.	AMMONIA.				NITROGEN AS		OXYGEN CONSUMED.		Chlorine.	*Residual Ammonia.	†Mil. Gals. Filtered per day.
	Free.	ALBUMINOID.			Nitrates.	Nitrites.					
		Total.	Dis-solved.	Sus-pended.			Un-filtered.	Filtered.			
Liquor, December, 1900	5.600	2.425	1.475	.950	.021	.0146	19.60	8.85	4.80	8.200	.022
Filtrate, " "	4.700	.570	.570	.000	.097	.0500	4.10	4.10	5.00	.900	
Per cent. removed	16.07	76.42	61.20	100.00	-361.90	-242.40	79.07	53.68	-4.17	89.02	
Liquor, January, 1901 ..	11.850	4.538	2.379	2.159	.034	.0441	23.45	13.36	16.13	8.625	.029
Filtrate, " " ..	8.500	1.035	1.035	.000	.024	.0344	9.22	9.22	15.93	2.700	
Per cent. removed	28.26	77.20	56.49	100.00	29.41	22.52	60.88	30.92	1.24	68.70	
Liquor, February, 1901	9.463	4.950	3.400	1.550	.042	.0694	23.20	16.30	13.00	10.563	.028
Filtrate, " "	8.088	1.663	1.663	.000	.044	.0778	10.43	10.43	10.53	3.038	
Per cent. removed	14.53	66.40	51.07	100.00	-4.76	-12.11	48.74	36.00	19.00	71.25	
Liquor, March, 1901	7.975	4.450	2.625	1.825	.090	.0760	24.76	14.22	9.68	8.888	.037
Filtrate, " "	5.900	1.119	1.119	.000	.082	.0825	7.96	7.96	6.58	2.788	
Per cent. removed	26.02	74.84	57.37	100.00	8.89	-8.55	67.84	44.02	32.03	68.63	
Liquor, April, 1901......	6.925	2.100	1.007	1.093	.032	.0490	19.21	10.82	5.43	2.825	.036
Filtrate, " "	5.400	.575	.575	.000	.061	.0424	6.06	6.06	4.60	.475	
Per cent. removed	22.02	72.61	42.91	100.00	-90.63	13.47	68.45	43.49	15.37	83.20	
Liquor, May, 1901	7.450	2.163	1.044	1.119	.037	.0405	15.59	11.09	5.98	4.181	.062
Filtrate, " "	5.575	.416	.416	.000	.091	.0165	5.42	5.42	4.93	.875	
Per cent. removed	25.17	76.12	60.16	100.00	-146.00	59.26	65.22	51.14	17.56	79.07	
Liquor, June, 1901......	9.750	1.956	1.200	.756	.099	.0270	14.99	8.30	5.13	5.813	.061
Filtrate, " "	7.125	.323	.323	.000	.041	.0129	4.81	4.81	4.60	.450	
Per cent. removed	26.93	83.51	73.08	100.00	58.59	52.22	68.32	42.05	10.33	92.21	
Liquor, July, 1901	9.290	1.590	.840	.750	.027	.0177	15.46	6.61	6.30	1.470	.154
Filtrate, " "	6.400	.386	.386	.000	.184	.0299	4.55	4.55	6.34	.000	
Per cent. removed	31.11	75.71	54.05	100.00	-581.50	-68.93	70.57	31.17	-0.64	100.00	
Liquor, August, 1901 ..	6.250	1.200	.719	.481	.061	.0319	11.86	5.87	8.33	2.738	.183
Filtrate, " " ..	4.381	.254	.254	.000	.013	.0029	3.41	3.41	8.48	.190	
Per cent. removed	29.90	78.83	63.28	100.00	78.68	90.90	71.24	41.91	-1.80	93.05	
Liquor, September, 1901	9.390	1.644	.804	.840	.044	.0150	15.50	6.62	10.15	1.594	.106
Filtrate, " "	4.980	.223	.223	.000	.044	.0011	3.33	3.33	10.50	.000	
Per cent. removed	46.96	86.44	72.26	100.00	0.00	92.66	78.50	49.69	-1.74	100.00	
Liquor, October, 1901 ..	20.50	1.788	1.088	.700	.051	.0148	18.47	9.45	12.70	.000	.016
Filtrate, " " ..	8.10	.385	.385	.000	.025	.0011	3.77	3.77	9.70	.000	
Per cent. removed	60.47	78.45	64.62	100.00	50.97	92.55	79.60	60.10	23.62	0.00	
Liquor, November, 1901	18.13	1.819	.676	1.143	.017	.0052	16.[illegible]6	8.72	7.22	.681	.029
Filtrate, " "	12.86	.338	.338	.000	.021	.0150	4.46	4.46	9.49	.035	
Per cent. removed	29.07	81.43	50.00	100.00	-23.54	-188.50	72.41	48.85	-32.56	94.86	
Liquor, Average, 1901 ..	10.20	2.318	1.276	1.042	.055	.0344	18.42	9.58	9.16	4.052	.066
Filtrate, " " ..	6.92	.516	.516	.000	.082	.0247	5.50	5.50	8.88	.635	
Per cent. removed	36.84	77.73	59.53	100.00	-49.16	28.17	70.17	42.61	3.05	84.33	

*The Residual Ammonia refers to the difference between the sum of the free and albuminoid ammonia and the ammonia obtained by the Kjeldahl method for nitrogen.

†Two acres of filter beds are in constant use for the filtration of the sludge press liquor.

The physical appearance of the tank has been very similar to that recorded in the report for 1900. There has at no time been any more than four inches in thickness of scum on the surface of the water.

June 28, 1901, the tank was cleaned out. At that time about 80,000 gallons of thin, finely divided sludge was removed from the basin. The dividing line between the sludge and the supernatant liquor was not clearly defined, and it would be very difficult to say just what proportion of the contents of the tank should be considered sludge. The sludge was very difficult to force through a filter press, and although six tons of lime were added to the sludge, the pressing was so slow and expensive that a portion of it was drawn on to the sludge liquor filter beds, and should the accumulation of this kind of sludge be at all large, the question of its disposal would be a serious one.

In this connection it might be stated that the crude sewage is taken to this basin through a 13-inch pipe a distance of from 300 to 400 feet, and it is quite likely that some of the solid matter in the sewage is not delivered to this basin.

In addition to this it should be stated that storm water has never been admitted to this treatment.

Much of the year there has been no scum on the surface, and rain and wind have caused what did appear from time to time to settle to the bottom of the basin. However, since the flow was increased to 500,000 gallons per day, and the amount of acid was decreased at the same time the strength of the sewage was increased, much more scum has appeared, but has never reached a thickness of over four inches. This thick scum has disappeared several times on account of wind or rain.

The disagreeable odors from this basin have continued as in the past, but are not, on account of the small area, as objectionable as the odors arising from the filter beds, on to which the effluent is turned. The odor from these beds is especially noticeable when the beds are covered with water, but during the remainder of the day the surface is so moist that the odor does not disappear. It would seem that this difficulty was one of the most serious in connection with the use of the sep-

of the water from the pond owned by the American Steel & Wire Company show that the pollution of the stream above the outlet of the sewer has remained the same as during the last two years. This would indicate that the improvement is the result of the efforts on the part of the city to carry out the obligation imposed by the Legislative Act of 1886.

In closing this report it is a pleasure to acknowledge the kindly interest in the work of the department shown at all times by the Committee on Sewers. The work of the Engineering Department has been maintained at its usual high efficiency. At this occasion it can not be out of place to credit the assistants in charge of the various branches of the work of this department with the interest and ability which have marked their work during the year, and to state that they have been largely instrumental in the success attained. Special mention should be made of the efficient manner in which Mr. Harry L. Dadmun superintended the pneumatic tunnelling done through Washington square.

During the year Mr. Julius W. Bugbee, for several years in charge of the purification works, has severed his connection with this department, and assumed charge of a similar plant for the city of Providence, R. I. Mr. Bugbee's efficient work here warrants his call to a more responsible position, and assures his continued success.

TABLE XXIV.

RESULTS OF SEPTIC TANK TREATMENT OF SEWAGE, JULY, 1900, TO DECEMBER, 1900.

(Parts per 100,000.)

	RESIDUE ON EVAPORATION.									AMMONIA.			
	TOTAL RESIDUE.			VOLATILE RESIDUE.			FIXED RESIDUE.			Free.	ALBUMINOID.		
	Total.	Solution.	Sus-pended.	Total.	Solution.	Sus-pended.	Total.	Solution.	Sus-pended.		Total.	Solution.	Sus-
Sewage, July, 1900......	71.3	44.6	26.7	44.2	34.5	9.7	27.1	10.1	17.0	1.270	.504	.268	
Effluent, " "	57.0	47.0	10.0	38.7	32.3	6.4	18.3	14.7	3.6	2.050	.400	.245	
Per cent. removed	20.06	-5.38	62.55	12.44	6.88	34.02	32.47	-45.54	78.82	-61.42	20.63	8.58	34
Sewage, August, 1900 ..	96.1	47.0	49.1	44.1	16.4	27.7	52.0	30.6	21.4	1.075	.424	.178	
Effluent, " " ..	64.6	44.6	20.0	25.0	13.9	11.1	39.6	30.7	8.9	1.894	.421	.143	
Per cent. removed	32.78	5.11	59.21	43.31	15.24	59.93	23.85	-0.36	58.41	-76.19	0.71	19.66	-14
Sewage, September, 1900	83.0	46.8	36.2	44.5	16.7	27.8	38.5	30.1	8.4	1.363	.717	.213	
Effluent, " "	53.6	39.6	14.0	19.1	11.7	7.4	34.5	27.9	6.6	1.769	.410	.169	
Per cent. removed	35.42	15.38	61.33	57.08	29.94	73.38	10.39	7.31	21.43	-29.79	42.82	20.66	52
Sewage, October, 1900..	79.0	50.1	28.9	43.2	20.5	22.7	35.8	29.6	6.2	1.455	.692	.166	
Effluent, " " ..	55.5	42.6	12.9	21.8	12.5	9.3	33.7	30.1	3.6	2.100	.394	.112	
Per cent. removed	29.75	14.97	55.36	49.54	39.02	59.03	5.87	-1.69	41.94	-44.33	43.06	32.53	46
Sewage, November, 1900	71.4	45.1	26.3	32.7	17.8	14.9	38.7	27.3	11.4	1.400	.610	.215	
Effluent, " "	53.9	44.9	9.0	18.0	12.3	5.7	35.9	32.6	3.3	1.963	.435	.143	
Per cent. removed	24.51	0.44	65.78	44.95	30.90	61.74	7.24	-19.41	71.05	-40.21	28.69	33.49	26

		NITROGEN AS		OXYGEN CONSUMED.						
	Residual.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Chlorine.	Total Iron as Copperas. Lbs. per Mil. Gals.	Free Sulphuric Acid. Lbs. per Mil. Gals.	Total Flow Through Tank.	Average Flow Per Day.
Sewage, July, 1900	1.360	.032	.0014	6.97	4.15	7.06	3,473	172	7,800,000	251,613
Effluent, " "	1.125	.022	.0004	6.01	3.21	8.30	3,867	82	Closed Sundays.	
Per cent. removed	17.28	31.25	71.43	13.77	22.65	....	11.34	52.33	....	....
Sewage, August, 1900.	1.225	.044	.0169	6.77	4.64	7.23	3,149	131	8,100,000	261,290
Effluent, " " ...	.919	.042	.0005	6.32	2.99	7.63	4,297	151	Closed Sundays.	
Per cent. removed	24.90	4.59	97.04	66.47	35.56	....	-36.46	-15.27	....	....
Sewage, September, 1900	1.706	.031	.0095	8.80	5.78	6.88	4.438	666	7,800,000	260,000
Effluent, " "	.944	.012	.0002	5.91	3.44	6.78	4,411	689	Closed Sundays.	
Per cent. removed	44.66	61.29	97.89	32.84	40.48	....	0.61	-3.47	....	....
Sewage, October, 1900..	1.405	.060	.0380	8.16	5.88	6.56	4.457	941	8,100,000	261,290
Effluent, " " ..	.950	.028	.0026	6.25	4.27	6.76	3,651	1,018	Closed Sundays.	
Per cent. removed	32.38	53.33	93.16	23.41	27.38	....	18.08	-8.18	....	....
Sewage, November, 1900	1.788	.075	.0104	7.42	5.74	5.88	4.441	1,166	7,800,000	260,000
Effluent, " "	1.188	.030	.0026	6.18	4.40	6.15	4,297	998	Closed Sundays.	
Per cent. removed	76.14	60.00	75.96	16.71	23.34	....	3.24	14.41	....	....

TABLE XXV

RESULTS OF SEPTIC TANK TREATMENT O
DECEMBER, 19

[Parts per 100,00

	RESIDUE ON EVAPORATI						
	TOTAL RES.			VOL. RES.			F
	Total.	Sol.	Susp.	Total.	Sol.	Susp.	Total.
Sewage, Dec., 1900....	57.76	45.82	11.94	20.92	13.19	7.73	36.8
Effluent. " " ...	55.59	46.92	8.67	17.99	12.24	5.75	37.6
Per cent. removed	3.75	-2.40	27.39	14.01	7.20	25.61	2.0
Sewage, Jan., 1901....	90.1	56.7	33.4	59.3	35.0	24.8	30.8
Effluent, " "	58.6	48.5	10.1	30.5	24.6	5.9	28.1
Per cent. removed	34.96	14.46	69.76	48.57	29.71	75.72	8.71
Sewage, Feb., 1901....	101.9	48.7	53.2	68.8	27.4	40.9	33.6
Effluent, " "	61.3	44.3	17.0	31.8	21.1	10.7	29.5
Per cent. removed	39.96	9.04	68.05	53.44	22.99	73.84	12.2
Sewage, March, 1901..	68.6	45.4	23.2	38.3	25.0	13.3	30.3
Effluent, " " .	59.7	38.2	21.5	29.6	18.4	11.2	30.1
Per cent. removed	12.97	15.86	73.26	22.72	26.40	15.79	0.6
Sewage, April, 1901...	93.0	47.1	45.9	47.7	19.1	28.6	45.3
Effluent, " " ...	60.3	43.0	17.3	22.3	12.3	10.0	38.0
Per cent. removed	35.16	8.71	62.32	53.25	38.09	65.03	16.1
Sewage, May, 1901....	63.8	42.5	21.3	30.4	16.1	14.3	33.4
Effluent, " "	49.1	34.7	14.4	16.7	10.7	6.0	32.4
Per cent. removed	23.14	18.35	32.39	45.06	33.55	57.99	3.0
Sewage, June, 1901...	79.2	51.6	27.6	39.1	22.5	16.6	40.1
Effluent, " " ...	58.0	39.0	19.0	33.2	16.2	17.0	24.8
Per cent. removed	26.77	24.42	30.45	15.09	28.00	-2.41	38.33
Sewage, July, 1901....	95.1	71.8	23.3	54.2	29.6	24.6	50.9
Effluent, " "	70.8	56.5	14.3	26.3	14.2	12.1	44.5
Per cent. removed	25.55	21.31	38.60	51.47	52.02	50.82	12.54
Sewage, August, 1901.	106.1	68.2	37.9	52.0	26.0	26.0	54.1
Effluent, " " .	67.5	51.4	16.1	21.7	14.3	7.4	45.8
Per cent. removed	36.39	24.63	57.53	58.26	45.00	71.53	15.34
Sewage, Sept., 1901...	100.2	69.6	30.6	55.6	35.4	20.2	44.6
Effluent, " " ...	72.4	49.0	23.4	28.8	18.0	10.8	43.6
Per cent. removed	27.74	29.60	23.53	48.19	49.15	46.52	2.24
Sewage, Oct., 1901....	91.5	51.9	39.6	45.8	23.0	22.8	45.7
Effluent, " "	72.7	38.0	34.7	32.5	16.1	16.4	40.2
Per cent. removed	20.55	26.78	12.37	29.04	30.00	28.07	12.03
Sewage, Nov., 1901....	90.0	54.1	35.9	42.9	24.9	18.0	47.1
Effluent, " "	73.9	45.5	28.4	38.5	23.2	15.3	35.4
Per cent. removed	17.88	15.90	20.89	10.26	6.83	15.00	24.84
Average sewage, 1901.	87.9	55.3	32.6	46.3	26.0	20.3	41.6
Average effluent, 1901.	65.3	44.5	20.8	28.5	17.2	11.3	36.8
Per cent. removed	25.71	19.53	38.20	38.44	33.85	44.33	11.53

	Number of Bacteria per 1 C. C.	Average Flow per acre per Day
	.. ...	
	. ... .	185,181
Sewage, Dec., 1900....	....	....
Effluent, " "		
Per cent. removed	5 2,204,000	... ..
	44,300	124,129
	97.99	.....
Sewage, Jan., 1901		
Effluent, " "		
Per cent. removed	5 1,569,000	....
	20,100	69,708
	98.72	......
Sewage, Feb., 1901....		
Effluent, " "		
Per cent. removed	3 1,206,000	......
	38,800	147,379
	96.90	.....
Sewage, March, 1901..		
Effluent, " " ..		
Per cent. removed	6 2,444,000	....
	30,900	60,574
	98.72	......
Sewage, April, 1901...		
Effluent, " " ...		
Per cent. removed	1,467,000	....
	14,500	98,180
	99.04	......
Sewage, May, 1901....		
Effluent, " "		
Per cent. removed	2 ,705,000	......
	76,700	84,375
	95.50	.....
Sewage, June, 1901....		
Effluent, " "		
Per cent. removed	6 ,590,000	......
	71,300	42,857
	95.35	.....
Sewage, July, 1901....		
Effluent, " "		
Per cent. removed	4 ,152,000	......
	75,400	60,686
	93.30	......
Sewage, August, 1901.		
Effluent, " " .		
Per cent. removed	9 ,430,000	......
	13,800	68,958
	99.03	......
Sewage, Sept., 1901 ...		
Effluent, " " ...		
Per cent. removed	- ,733,000	......
	27,700	84,074
	99.26	......
Sewage, Oct., 1901.....		
Effluent, " "		
Per cent. removed	9 947,000	......
	46,800	92,835
	98.81	......
Sewage, Nov., 1901		
Effluent, " "		
Per cent. removed	8	
	131,000	......
	41,900	93,245
	98.04	......
Average sewage, 1901.		
Average effluent, 1901.		
Per cent. removed		

5 1 albuminoid

NOTE.—The residual and the ammonia obtaine

RESULT

TABLE XXV—Continued.

	Nitrogen as		Oxygen Consumed								Average Temp	
	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Chlorine.	Total Iron as Copperas. Lbs. per Mil. Gals.	Free Sulphuric Acid. Lbs. per Mil. Gals.	Total Flow Through Tank.	Average Flow per Day.	Number of Bacteria per 1 C.C.	Maximum.	Minimum.
Sewage, July	.121	.0199	6.24	4.89	5.15	4.235	227	4,400,000	[illegible]	1,752,000	....	..
Effluent, "	.068	.0093	5.20	3.45	5.28	3.919	371	....	....	1,467,000	....	
Per cent	44	53.27	16.67	29.45	......	7.46	-63.44	....	....	....	....	..
Sewage, Aug	.140	.0098	12.97	8.83	6.94	3.904	329	4,100,000	281,290	5,236,000	52.2	[illegible]
Effluent,	.032	.0010	9.37	6.27	6.86	4.115	260	....	....	1,705,000	47.9	[illegible]
Per cent	77	96.46	27.76	29.00	......	-5.41	20.97	....	....	....	...	
Sewage, Sept	.057	.0294	12.30	8.38	7.63	4.307	642	7,200,000	257,143	7,087,000	47.9	[illegible]
Effluent,	.020	.0018	9.60	6.75	7.45	2.687	265	....	....	1,300,000	45.9	[illegible]
Per cent	58	93.79	21.87	19.45		38.77	58.72	....	....	....	......	
Sewage, Oct	.117	.0364	11.31	7.34	6.40	2.838	470	5,081,250	163,911	5,550,000	47.7	[illegible]
Effluent,	.045	.0020	8.89	5.11	6.35	3.431	247	....	....	2,152,000	47.4	[illegible]
Per cent	53	94.52	21.40	30.38	..	-20.97	47.44	....	....	....	......	
Sewage, Nov	.113	.0350	9.40	6.75	5.69	4.413	673	7,125,000	237,500	6,490,000	49.3	[illegible]
Effluent,	.081	.0125	7.48	4.89	5.58	3.324	630	....	....	1,430,000	58.1	[illegible]
Per cent	28.30	64.28	20.43	27.55	....	24.68	6.39	....	....	....	......	
	.095	.0731	5.93	3.94	5.03	3.558	961	9,025,000	258,871	2,457,000	55.7	[illegible]
	.046	.0016	4.38	2.54	4.98	3.318	900	....	....	3,373,000	56.4	[illegible]
	49.23	97.81	26.13	32.06	......	6.75	4.53	....	....	....	......	
	.113	.0365	5.65	3.38	5.75	4.257	909	7,800,000	260,000	3,614,000	62.0	[illegible]
	.040	.0010	5.54	2.82	5.48	2.777	1,047	....	....	3,947,000	67.5	[illegible]
	64.60	97.26	1.95	16.57	......	34.77	-15.18	....	....	....	......	
	.150	.0375	7.56	5.28	7.58	6.420	1,184	6,156,250	198,589	3,987,000	73.7	[illegible]
	.083	.0012	4.48	3.37	8.23	5.590	1,465	....	....	1,765,000	75.6	[illegible]
	44.67	96.81	40.66	37.87	......	12.93	-23.72	....	....	....	......	
	.040	.0250	9.51	5.30	8.43	6.909	834	9,162,500	295,565	2,531,000	75.7	[illegible]
	.022	.0013	5.28	3.17	8.53	5.090	977	....	....	1,873,000	75.9	[illegible]
	44.99	94.79	44.47	40.22	......	26.76	-17.14	....	....	....	......	
	.077	.0123	10.92	6.79	12.62	4.844	1,309	14,072,900	469,097	3,390,000	69.2	[illegible]
	.039	.0011	6.55	4.42	12.70	4.643	975	....	....	1,374,000	70.1	[illegible]
Sewage, July	[illegible]	91.06	39.47	34.90	......	4.15	23.16	....	....	....	......	
Effluent, " Per cent.	.084	.0408	12.48	7.00	9.39	3.794	944	14,906,250	480,847	1,986,000	63.1	[illegible]
	.008	.0012	7.10	4.87	9.29	3.446	974	....	....	2,890,000	63.1	[illegible]
Sewage, Aug.	90	97.10	42.52	30.40	......	9.17	-3.18	....	....	....	......	
Effluent, " Per cent.	[illegible]	.0713	15.28	9.37	9.83	3.790	1,006	14,375,000	479,167	2,987,000	58.3	[illegible]
	[illegible]	.0013	9.00	7.12	9.24	3.858	1,044	....	....	5,167,000	57.3	[illegible]
Sewage, Sept.	[illegible]	98.17	41.12	24.02		-1.79	-3.79	....	....	....	......	
Effluent, " Per cent.												
	.070	.0351	10.54	6.60	9.16	4.399	838	9,310,346	302,746	3,712,000	59.6	[illegible]
Sewage, Oct.	.031	.0024	7.03	4.74	8.06	3.888	810	....	....	2,539,000	60.0	[illegible]
Effluent, " Per cent.	[illegible]	93.17	33.29	29.15	...	11.52	3.34	....	....	....	......	
Sewage, Nov. Effluent, Per cent.												

[illegible] represents the difference between the sum of the free and albuminoid ammoni [illegible] by the Kjeldahl method for nitrogen

TABLE XXVI.

RESULTS OF FILTRATION OF SEPTIC TANK EFFLUENT.

Monthly Averages of Weekly Analyses of Sterilized Daily Samples.

(Parts per 100,000.)

ATE OF COLLECTION.	AMMONIA.				NITROGEN AS			OXYGEN CONSUMED.		Chlorine.	Total Iron as Copperas. Lbs. per Mil. Gals.	Free Sulphuric Acid. Lbs. per Mil. Gals.	Number of Bacteria per 1 C. C.	Average Flow per acre per Day.
	Free.	ALBUMINOID.			Residual.	Nitrates.	Nitrites.	Un-filtered.	Filtered.					
		Total.	So-lution.	Sus-pended.										
ffluent, July, 1900	2.050	.400	.245	.155	1.125	.022	.0004	6.01	3.21	8.30	3,867	82	....	......
iltrate, " "	3.140	.161	.161	.000	.330	.027	.0022	1.77	1.77	7.60	5,757	43	....	185,181
Per cent. removed	-53.16	59.74	34.29	100.00	86.68	....	....	70.53	44.86	....	-28.40	47.56	....	......
ffluent, August, 1900 ..	1.894	.421	.143	.278	.919	.042	.0005	6.32	2.99	7.63	4,297	151	2,204,000	.....
iltrate, " " ..	3.363	.194	.194	.000	.400	.048	.0191	1.11	1.11	7.63	4,182	263	44,200	124,129
Per cent. removed	-77.57	53.92	-35.67	100.00	56.48	....	....	82.43	62.88	....	2.68	-74.16	97.99	......
ffluent. September, 1900	1.769	.410	.169	.241	.944	.012	.0002	5.91	3.44	6.78	4,411	689	1,569,000	......
iltrate. " "	2.713	.145	.145	- .000	.325	.193	.3289	0.76	0.76	7.05	3 914	1,174	20,100	69,708
Per cent. removed	-58.37	64.63	14.70	100.00	65.57	....	....	87.14	77.89	....	11.27	-70.39	98.72	......
ffluent. October, 1900..	2.100	.394	.112	.282	.950	.028	.0026	6.25	4.27	6.76	3,651	1,018	1,266,000	......
iltrate. " " ..	1.460	.094	.094	.000	.310	.070	.2416	0.87	0.87	6.66	2,458	1,081	38,800	147,379
Per cent. removed	30.45	76.12	16.03	100.00	67.38	....	....	86.08	79.64	....	32.68	-6.19	96.90	......
ffluent. November, 1900	1.963	.435	.143	.292	1.188	.030	.0026	6.18	4.40	6.15	4,297	998	2,444,000	......
iltrate. " "	2.088	.081	.081	.000	.138	.179	.1720	0.72	0.72	6.15	1,368	1,260	30,900	60,574
Per cent. removed	-6.37	81.37	43.36	100.00	88.37	....	....	86.34	83.62	....	67.53	-26.25	98.72	......
ffluent, December, 1900	1.875	.390	.181	.209	1.413	.058	.0093	5.20	3.45	5.28	3,919	371	1,467,000	......
iltrate. " "	2.550	.046	.046	.000	.106	.143	.1315	0.41	0.41	5.33	1,950	735	14,500	98,180
Per cent. removed	-35.99	88.41	74.59	100.00	92.49	....	....	92.10	90.18	....	50.24	-98.11	99.04	......
ffluent, January, 1901	3.040	.634	.418	.216	1.570	.032	.0010	9.37	6.27	6.86	4,115	260	1,705,000	......
iltrate. " "	2.450	.153	.153	.000	.410	.044	.0105	1.39	1.39	6.60	2,266	433	76,700	84,375
Per cent. removed	-19.41	75.86	63.24	100.00	73.89	....	....	85.15	77.82	....	44.83	-66.53	95.50	......
ffluent, February, 1901	2.975	.628	.338	.290	1.825	.039	.0018	9.68	6.75	7.45	2,637	265	1,520,000	......
iltrate, " "	2.913	.209	.209	.000	.494	.024	.0057	1.90	1.90	7.30	2,744	671	71,300	42,857
Per cent. removed	2.08	66.71	39.05	100.00	73.10	....	....	80.37	57 59	....	-4.06	-153.20	95.35	......
ffluent, March, 1901 ..	2.663	.691	.371	.320	1.788	.045	.0020	8.68	5.11	6.35	3,431	247	2,152,000	......
iltrate, " " ..	2.750	.161	.161	.000	.318	.028	.0035	1.61	1.61	5.90	2,179	289	75,400	60,686
Per cent. removed	-3.27	76.70	56.59	100.00	82.21	....	....	81.45	68.48	....	36.42	-17.00	93.30	......
ffluent, April, 1901	1.630	.409	.195	.214	.800	.081	.0125	7.48	4.89	5.58	3,324	630	1,430,000	......
iltrate, " "	1.825	.082	.082	.000	.283	.051	.0441	1.09	1.09	5.18	1,375	630	13,800	68,958
Per cent. removed	-11.96	79.95	57.95	100.00	64.31	....	....	85.43	77.71	....	58.64	0.00	99.03	......
ffluent, May, 1901......	1.788	.351	.126	.225	.750	.046	.0016	4.38	2.54	4.98	3,318	900	3,733,000	......
iltrate. " "	.863	.073	.073	.000	.200	1.331	.4593	0.72	0.72	4.83	883	943	27,700	84.074
Per cent. removed	51.72	79.20	42.07	100.00	73.33	....	...	84.14	71.45	....	72.00	-4.80	99.26	......
ffluent, June, 1901	1.944	.380	.131	.249	.925	.040	.0010	5.54	2.82	5.48	2,777	1,047	3,947,000	......
iltrate, " "	.489	.048	.048	.000	.208	.422	.2388	0.55	0.55	5.35	409	108	46,800	92,835
Per cent. removed	74.85	87.36	63.36	100.00	77.52	....	....	90.06	80.50	....	85.27	90.00	98.81	......
verage Effluent, ...	2.057	.462	.214	.248	1.183	.042	.0029	6.75	4.18	6.47	3,640	555	2,131,000	......
" Filtrate, ...	2.303	.120	.120	.000	.294	.198	.1299	1.09	1.09	6.27	2,728	578	41,900	93,245
Per cent. removed	-11.96	74.03	43.92	100.00	75.15	....	....	83.85	73.98	....	25.05	-4.14	98.04	......

NOTE.—The Residual Ammonia represents the difference between the sum of the free and albuminoid amonia and the ammonia obtained by the Kjeldahl method for nitrogen.

TABLE XXVII.

AVERAGES OF WEEKLY ANALYSES OF WATER FROM THE BLACKSTONE RIVER

FROM DECEMBER, 1900, TO JULY, 1901, JULY, 1901, TO DECEMBER, 1901, AND FROM DECEMBER, 1900, TO DECEMBER, 1901.

[Parts per 100,000.]

WHERE TAKEN	DATE OF COLLECTION	Free Ammonia	Total Albuminoid Ammonia	Nitrogen as Nitrates	Nitrogen as Nitrites	Total Oxygen Consumed	Chlorine
Am. Steel & Wire Co. pond	Dec. 1, 1900, to July 1, 1901	.048	.048	.040	.0018	0.94	0.68
" " " " " "	July 1, 1901, to Dec. 1, 1901	.026	.054	.040	.0037	1.16	0.88
" " " " " "	Dec. 1, 1900, to Dec. 1, 1901	.036	.050	.045	.0026	1.08	0.78
Bridge	Dec. 1, 1900, to July 1, 1901	.224	.101	.081	.0055	2.05	1.91
"	July 1, 1901, to Dec. 1, 1901	.109	.070	.068	.0048	1.46	2.27
"	Dec. 1, 1900, to Dec. 1, 1901	.198	.088	.074	.0050	1.80	2.06
Swamp	Dec. 1, 1900, to July 1, 1901	.879	.125	.066	.0145	2.08	2.84
"	July 1, 1901, to Dec. 1, 1901	.484	.068	.047	.0190	1.06	3.78
"	Dec. 1, 1900, to Dec. 1, 1901	.428	.101	.057	.0184	1.68	2.78
Morse pond	Dec. 1, 1900, to July 1, 1901	.882	.080	.044	.0100	1.27	2.84
" "	July 1, 1901, to Dec. 1, 1901	.580	.088	.084	.0181	1.27	4.54
" "	Dec. 1, 1900, to Dec. 1, 1901	.466	.081	.089	.0110	1.27	3.19
Aldrich pond	Dec. 1, 1900, to July 1, 1901	.826	.078	.052	.0070	1.19	2.01
" "	July 1, 1901, to Dec. 1, 1901	.580	.088	.086	.0140	1.27	4.86
" "	Dec. 1, 1900, to Dec. 1, 1901	.484	.080	.044	.0100	1.19	3.00

TABLE XXVIII.

RELATIVE CONDITION OF THE BLACKSTONE RIVER FROM 1893 TO 1901 INCLUSIVE.

	TOTAL ALBUMINOID AMMONIA. (Parts per 100,000.)									TOTAL OXYGEN CONSUMED. (Parts per 100,000.)								
	1893	1894	1895	1896	1897	1898	1899	1900	1901	1893	1894	1895	1896	1897	1898	1899	1900	1901
AM. STEEL & WIRE CO.'S POND.																		
December to July.	——	.023	.032	.025	.022	.024	.027	.039	.048	——	0.74	0.75	0.64	0.59	0.48	0.73	0.89	0.94
July to December.	.052	.054	.050	.042	.037	.039	.085	.064	.054	1.21	0.87	1.14	0.64	0.67	0.77	1.42	1.00	1.16
Average for year.	.047	.037	.039	.032	.028	.030	.051	.050	.050	1.03	0.79	0.90	0.64	0.62	0.60	1.01	0.94	1.03
BLACKSTONE RIVER, BRIDGE.																		
December to July.	——	.047	.050	.047	.037	.047	.076	.103	.101	——	0.95	0.96	0.72	0.74	0.88	1.08	1.63	2.05
July to December.	.085	.062	.056	.060	.048	.071	.070	.084	.070	1.40	0.95	1.05	0.76	1.08	1.09	1.44	1.35	1.46
Average for year.	.103	.053	.052	.053	.042	.057	.073	.095	.088	1.51	0.95	1.00	0.74	0.88	0.96	1.23	1.51	1.80
BLACKSTONE RIVER, SWAMP.																		
December to July.	——	.129	.109	.096	.085	.115	.110	.143	.125	——	1.21	1.30	0.80	0.89	1.02	1.03	1.86	2.08
July to December.	.377	.178	.139	.150	.127	.105	.135	.159	.068	2.41	1.60	1.24	1.23	1.24	1.16	1.55	2.02	1.06
Average for year.	.282	.150	.122	.118	.103	.111	.114	.150	.101	2.12	1.36	1.27	0.99	1.04	1.08	1.24	1.93	1.68
MORSE'S POND.																		
December to July.	——	.108	.093	.097	.082	.067	.081	.130	.080	——	1.17	1.15	0.94	0.92	0.65	1.01	1.31	1.27
July to December.	.211	.157	.157	.141	.119	.121	.129	.112	.083	1.37	1.41	1.24	1.06	1.07	1.12	1.54	1.34	1.27
Average for year.	.175	.129	.120	.115	.098	.089	.100	.121	.081	1.43	1.27	1.19	1.00	0.98	0.84	1.20	1.32	1.27
ALDRICH'S POND.																		
December to July.	——	.101	.082	.088	.074	.061	.075	.087	.078	——	1.12	0.95	0.90	0.79	0.87	0.75	0.93	1.12
July to December.	.172	.151	.132	.152	.108	.168	.083	.098	.083	1.18	1.27	1.08	0 89	0.85	0.86	1.48	1.06	1.27
Average for year.	.135	.122	.112	.106	.089	.064	.078	.092	.080	1.09	1.18	1.01	0.90	0.81	0.87	1.05	0.98	1.19

TABLE XXIX.

CONDITION OF BLACKSTONE RIVER BELOW THE SEWAGE PRECIPITATION WORKS.

FROM STATE BOARD OF HEALTH.

(Parts per 100,000.)

MONTHS	Color	Residue on Evaporation		Ammonia.				Chlorine	Nitrogen as		Hardness
		Total	Loss on Ignition	Free	Albuminoid.				Nitrates	Nitrites	
					Total	Dissolved	Suspended.				
June November, 1887	0.91	.....	....	.2686	.1741	.....	...	1.85	.0160	.....	. .
" " 1888	0.76	......	...	.2658	.1112	.0557	.0555	1.50	.0382	.0041	. .
" " 1889	0.86	...	..	.3980	.1430	.0772	.0658	1.32	.0177	.0026	
" " 1890	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	0.270	.0018	3.9
" " 1891	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892	0.68	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0187	.0050	10.3
" " 1893	0.51	30.00	7.13	.5680	.1458	.0900	.0558	2.76	.0285	.0126	10.9
" " 1894	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.68	.0212	.0071	10.6
" " 1895	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.8
" " 1896	0.30	26.03	6.58	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897	0.78	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898	0.23	25.63	6.78	.3064	.0868	.0560	.0308	1.55	.0182	.0119	9.2
" " 1899	0.14	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108	.0068	16.1
" " 1900	0.22	24.57	4.48	.4480	.1249	.0621	.0628	2.13	.0110	.0145	7.3
" " 1901	0.09	31.12	6.90	.4580	.1293	.0772	.0521	3.42	.0090	.0058	10.8

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